Vol. XXXVII. JUNE, 1897.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

TRANSACTIONS.

No. 802.

THE INFLUENCE OF RAILS ON STREET PAVEMENTS.

By EDWARD P. NORTH, M. Am. Soc. C. E.

PRESENTED DECEMBER 16TH, 1896.

WITH DISCUSSION.*

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its very brutality partially defeated its object, as a heavily loaded wagon once on the line of such rails leaves it with extreme reluctance. It is, however, largely employed on the surface roads of the city of New York, and it has required an act of the legislature to prevent a further extension of its use. A modification of this rail, Fig. 9, has also been introduced, and is used as a girder rail on one of the cable lines in this city.

The side-bearing rail shown in Fig. 4 as a girder rail presents a very good wheelway for vehicles once between the rails, and thus far is better than the Hewitt rail; but on account of its nearly vertical sides, it is very hard to pull a loaded wagon out of the track, and in crossing at a small angle with a light vehicle at any speed, the jerk is about as severe as on the center-bearing rail. A rail of this section is also used as a strap rail, being spiked to longitudinal stringers, as is the center-bearing rail generally.

Figs. 7 and 8 show sections that are employed as guard rails on curves and otherwise. They also are strap rails, and when laid on curves, it is almost impossible to make the spikes hold so well that water will not splash out from under them. The only excuse for their use is that bending them costs less than bending a girder rail, and, in general, the use of a strap rail on any highway should be prohibited after a near date in all self-respecting countries.

When permission was given to lay a cable road on Broadway, in New York City, both the previously mentioned forms of rail were so strenuously objected to that the Commissioner of Public Works prescribed a grooved rail, as shown in Fig. 5. This was followed on the Third Avenue line by a rail shown in Fig. 2, and on the Twenty-eighth and Twenty-ninth Street road the section shown in Fig. 6 was adopted. All of these rails are improvements on any of the forms of rails before mentioned, but all of them are objectionable in that the flange is lower than the tread, which results in an unnecessary unevenness in the pavement, and in Fig. 6 the slot is so narrow and the sides so steep that there is difficulty in keeping it clean.

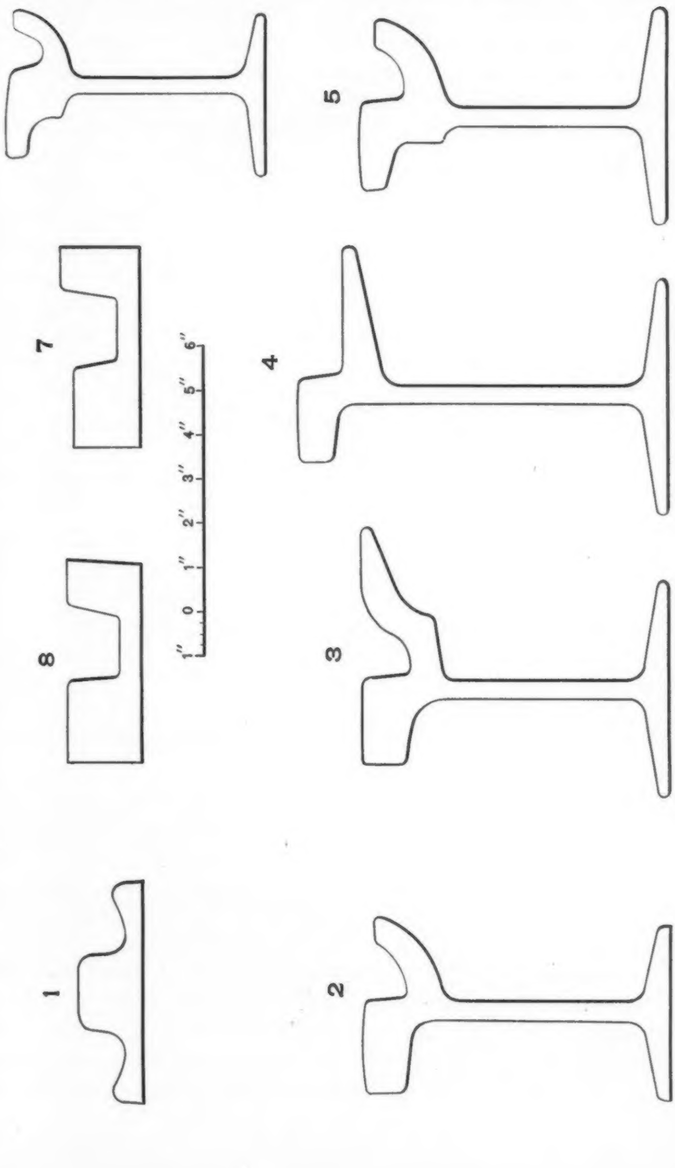
In the spring of 1895, the Metropolitan Traction Company, intending to lengthen its lines materially, presented to the Commissioner of Public Works, through the Hon. John D. Crimmins, at that time its managing director, a form of rail which, after some slight modification, was adopted. It is shown in Fig. 3. Except that the rail should

have been 9 ins. deep, instead of only 7, this section is possibly the best that has been introduced in this country.

There is abundant depth for the wheel flanges, while the curved flange on the rail allows obstructions to pass out easily, and materially aids a narrow-tired carriage wheel in getting out, as, the moment it assumes any angle, it is lifted up the curve by the reaction against the nearly vertical sides of the tread.

The value of this rail depends on the fact that the slot is so narrow that the wheels of a truck cannot sink into it, and, with the pavement just flush with the tread and flange, there is nothing to keep a wheel on it, so that, not only will there be no difficulty in pulling out of it, but horses will not be constantly reminded by an increase of traction that it is their duty to follow the line of the rail. In fact where this rail has been laid, no wagon with a tire over 1½ ins. wide has been observed by the author to follow it, though when a light wagon is once in it, the horse inclines to follow the rail. This, however, results in minimum annoyance to the railroad company, as light vehicles are nearly always prompt to leave the line of rails on the approach of a car, however difficult it may be. One other form of side-bearing rail, Fig. 10, is shown. This rail has not been laid in the City of New York, though the Commissioner of Public Works was approached by a surface railroad company that wished to lay it. It will be noticed that it is a side-bearing rail, with some of the vices of the Hewitt rail added. Undoubtedly, if its use had been permitted, it would have accomplished its object, namely, the confiscation of about 15 ft. of one of the principal lines of traffic.

Heretofore, where it has been thought necessary to use T rails in the streets of a city, for the passage of either trains or isolated freight cars, the stones have not been paved near the inner side of the rail, but a space of 2 or 3 ins. between the rail and the stones is left, which often becomes of profound depth. Walter Katté, M. Am. Soc. C. E., Chief Engineer of the New York Central and Hudson River Railroad, devised the compound section shown in Fig. 11. This combination allows the paving blocks to have a side-bearing near their top, on the flange side of the rail, and prevents any wheel which parallels the rail dropping indefinitely between the paving blocks and the rail. The clearance for the wheel flanges, however, is unnecessarily great, as is also the depth for their accommodation, and, on the outside of the


6
5
7
4
8
3
1
2
1″ 0 1″ 2″ 3″ 4″ 5″ 6″

rail, the paving block can only be brought in contact with the head of the rail by chipping off a corner, which every one knows is extremely unsatisfactory, as it is almost impossible to keep a paving block in position which has been so treated.

When the Central Railroad Company of New Jersey applied to the

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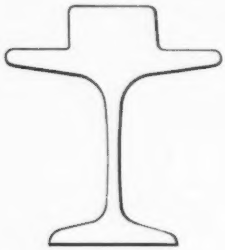

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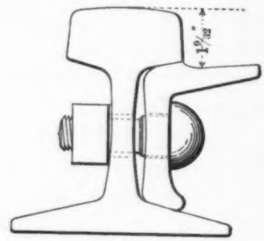

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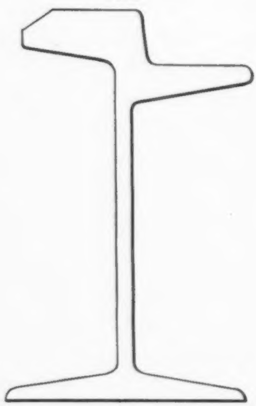

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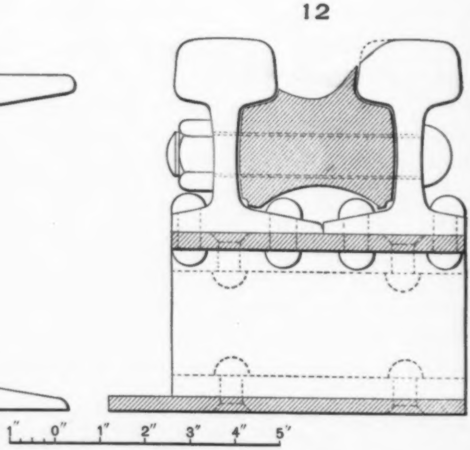

Commissioner of Public Works of this city for permission to cross Eleventh and Thirteenth Avenues near Fifteenth Street, with tracks leading from a car ferry landing to its yard west of Eleventh avenue, Mr. J. H. Thompson, its Engineer of Construction, presented a combination shown in Fig. 12. The rails used were the standard 60-lb. rails of the

road, with a cast-iron filler between them, and a corner of the guard rail cut off; the lower flanges of these rails, as shown, are also planed off, and the combination is bolted to a wrought-iron chair. This combination, it will be observed, gives a nearly perfect side-bearing to the paving blocks, so that they can be laid without chipping, and it is hoped will keep their place rigorously. The cast-iron filler is so formed that, with the planed-off corner of the guard rail, any wheel can get out of the slot with ease. The clearance between the two rails is left as wide as it is, because a part of the track is laid on a 16° curve. This is submitted as the best combination yet offered by any railroad company for taking steam traffic through the streets of a city.

The satisfactory adjustment of the pavement to the rails presents some difficulties. Stone blocks can be solidly laid against wooden stringers, but the stringers soon rot sufficiently to let the rail down, and the joint then becomes unsatisfactory. With all girder rails of such section that both the tread and top flange are as wide, or wider, than the bottom flange, hard terra-cotta fillers moulded to the concave lines of the section and set in cement mortar give good bearings for the blocks. It is always advantageous, however, to have the height of the girder rail greater than the depth of the paving blocks. In setting these blocks the surface of the concrete should be left low, and the blocks next the rails laid in cement mortar. All ramming should be done before the initial set of the cement.

An asphalt pavement cannot be laid successfully against a wooden stringer ; in such cases toothing blocks are a necessity. With girder rails the noise from toothing blocks may be obviated by their omission. The first cost is less, but the maintenance account will be greater, as the rails so absorb and hold the heat during hot summer days that the asphalt next to them is kept soft for some time after sundown, and if the traffic follows the rails, a crease is formed that requires repairs, which the railways are generally slow to make. When granite toothing is laid, it is better to lay alternating blocks of 6 and 12-in. lengths at right angles to the rail. Eight-inch headers and stretchers are sometimes laid, but they are not economical, except on streets of very light traffic.

In place of granite or brick toothing a steel plate about $\frac{3}{8}$ in. thick and 3 ft. wide, punched with staggered holes, has been offered. As the arrangement was patented, its specification in any contract

with the city was prohibited by law. A small piece of this plate was laid in Chambers Street, where it was very satisfactory, preventing the formation of any rut.

While the section of rail adopted for most of the surface roads is obstructive to the rights and interests of the public, the style in which the space between the rails and between the tracks is maintained is often intentionally made much more obstructive. The laws of the State of New York,* make it obligatory on all surface roads to pave and keep in repair the space between the rails and tracks and 2 ft. outside of the same, but it provides no adequate penalty for non-compliance with the law. The only recourse known in the City of New York is to pave the space and charge it to the railway company, or to leave the area to the public spirit of the corporations. Eighth Avenue from Thirteenth to Fifty-ninth Street shows the result of one course ; the other method has resulted in bills aggregating decidedly over $700 000 accumulating against the surface railways on Manhattan Island from 1889 to 1895, both years inclusive.

What may be termed the Eighth Avenue method has resulted in a pavement between the rails that is seldom used by even the most stolid truckman, while the space between the tracks defies traffic of all kinds. That company has in effect sequestered a strip on Eighth Avenue over 2 miles long and about 17 ft. wide, with no other warrant than a right of way for its cars. The injury to the property on that avenue and the increased cost of transportation in the city is so great that it seems inexplicable that no grand jury should have found a bill against the perpetrators of so malicious an outrage.

On the other hand, the plan of charging the cost of an improved pavement against the company, whose income is augmented by the increased value and greater circulation that follows better pavements, has cost the city on an average over $100 000 per annum for the past seven years. This money has been taken from the resources of the tax-payers, but it does not follow that it has resulted in a like gain to the corporations which so persistently and successfully defy the laws of this State.

It might not be worth while to occupy the attention of the Society with this question if it was a local one, but both in cities and on country roads the surface railways, whether actuated by horse-power

* Chapter 565, Section 98, Laws of 1890, as amended by Chapter 676, Laws of 1892.

or electricity, devastate the highway, using an easement for a right of way on the roads and streets with a haughty disregard of the rights of others that should not be allowed if they were held in fee. In spite of low freight rates on railroads and water-courses, this country has been injured, and, to some extent, impoverished, through the high cost of transportation on country roads, consequent upon their generally wretched condition. Concurrently with a general effort to so improve the surface of roads and streets that both transportation and circulation shall be cheaper and pleasanter, the success of these efforts are found to be threatened by the legal inability of local authorities to force owners of surface roads to maintain the area within and about their tracks in fair condition.

Some surface roads have procured charters which do not require them to maintain the pavement in and about their tracks. These claim that no additional burden can be laid on them. If this proposition is correct, it would seem to a layman that no increased rate of taxation could be levied against this property, but there seems nothing to prevent legislation which will allow municipalities and local officers in charge of roads prompt redress against corporations that now occupy the time of our courts in successful efforts to slight a duty imposed by their charters, or by general laws under which they are incorporated. Nor is there anything to prevent such legislation as will require those who are exploiting new roads, which will occupy highways, to pave, maintain and repave a much larger portion of the road or street than at present.

DISCUSSION.

Mr. Lewis. NELSON P. LEWIS, M. Am. Soc. C. E.—The pre-emption of the most important streets of cities to-day by railroad corporations, with no regard for the purposes for which such streets were primarily designed, the failure of the companies to live up to their charter obligations as to maintenance of pavements, and the frequent indifference and almost universal inability of public officials to secure from them a proper performance of their obligations, is one of the most conspicuous defects in modern municipal government in America. The manner in which sweeping franchises have been granted for an indefinite period for the occupation of the streets, with no attempt to protect the interests of city or citizen, can be characterized only as a stupendous piece of municipal folly, if not of municipal crime. There can be no proper reason why any future grants of this character should not be made for a fixed period, upon the expiration of which the road-bed and rails, if not the equipment, should become the property of the city, and all corporate or private rights in or to the streets become extinguished. However, conditions must be accepted as found. The charter and franchises have already been granted, and it is extremely probable that many more miles of street railroads will be built with no further restrictions than have already been imposed.

The questions now presented are: the proper construction, of such a character that it is possible to maintain a modern pavement along and between the tracks, and a guaranty of subsequent maintenance of pavement as well as track by the railroad company.

In construction the objects to be attained are durability, in order that the street surface need not be perpetually torn up for repairs, and the selection of a form of rail which will offer no obstruction to vehicles traveling along or across it, but will not invite them to follow it, and will not materially break the uniformity of surface of the pavement. The introduction of electricity as a motive power, with the enormous increase in the weight of cars, has resulted in the use of extremely heavy rails weighing from 90 to 100 lbs. per yard. The common method of track building with these rails presents a curious anomaly. Wooden cross-ties are placed upon soft earth and brought to a temporary surface by careless tamping. Upon them are laid heavy 9-in. girder rails, and the pavement is restored. It is only a matter of weeks or months before the tracks require resurfacing, and a perpetual tearing up of the pavement begins and continues for an indefinite period. Attempts have been made to improve upon this by laying a bed of concrete not less than 6 ins. in depth beneath the cross-ties, which are embedded in concrete. This has been done in Cinciunati, where sawed white oak ties are used, and the concrete is carried to the tops of the

ties where granite pavement is to be laid, or within 3 ins. of the top of the rail in the case of asphalt. Mr. H. J. Stanley, City Engineer, states that in over 40 miles of this construction which has been down several years no weak spots have developed. Full-grooved girder rails are used, 6 ins. deep on asphalt streets, and 8 ins. deep when granite or brick are to be used, and weighing, respectively, 86 and 95 lbs. per yard. Of course this is very expensive, but the railroad companies seem satisfied with the results. Samuel Whinery, M. Am. Soc. C. E., writes that in his opinion, a "broken stone foundation is entirely sufficient, and it offers opportunity for drainage, which is of advantage." Mr. Lewis.

In Toronto, Canada, under the direction of E. H. Keating, M. Am. Soc. C. E., what seems a further advance has been made in dispensing with the cross-ties altogether and laying 7-in. grooved girder rails directly upon a bed of concrete extending across the whole roadway, the concrete being apparently of the same thickness and quality under the rails as on the remainder of the roadway, the rails being kept to gauge by $2\frac{1}{4} \times \frac{3}{8}$-in. tie-rods. Mr. Keating says that the results in this case have been very satisfactory. In Minneapolis and St. Paul, the rails are laid on a longitudinal beam of Portland cement concrete.

In the opinion of the speaker the substitution of Portland cement concrete for perishable wooden cross-ties, as a support for the rails, is an important step towards a permanent track construction which will avoid the constant opening of the pavement for repairs.

Next as to the form of rail to be used. The side-bearing girder rail so generally in use at present divides the street pavement, if laid flush with the tread on one side and the flange on the other, into five sections, two of which are from 1 to $1\frac{1}{4}$ ins. below the remaining three; while in case granite blocks between the rails are laid at the level of the tread four troughs about 3 ins. wide will be left in the pavement. In either case the broad head presents irresistible attractions to the drivers of heavily loaded vehicles. The first efforts to remedy this trouble were naturally by the adoption of a grooved rail. The full-grooved rail, however, in which the flange and the tread are at the same elevation, was and is strongly opposed by the railroad companies on account of the difficulty of keeping the slot clean, and, it is claimed, of the danger due to inability to stop the cars quickly when the openings become filled with horse droppings, etc., and the great wear on, and breaking of, the wheel flanges when the groove is narrow. Grooved rails are being used to-day in a number of cities, including Washington, Cincinnati, Detroit and Buffalo, in which last a half-grooved rail (Fig. 13) was voluntarily adopted by the traction companies. The real reason for the objection is probably the greater cost of this form of rail. Few of the grooves are so narrow that wheels of light wagons will not get into them, and if the form recommended by Mr. North and shown in Fig. 3 be used, the writer fears that the

Mr. Lewis. noise made by wheels grinding along the curved flange and falling back into the grooves will be the cause of much complaint.

When electric traction was introduced in Brooklyn, the company operating a very large proportion of the total mileage of surface lines adopted what was known as the Lewis & Fowler girder rail, shown in Fig. 14. The municipal authorities appear to have acquiesced either from indifference or because the rail appeared to be a favorable one to lay pavement against. It would be difficult to design a section having the same amount of metal so disposed as to be less effective, and the failure which might have been predicted soon resulted. A serious objection to this form of rail was the noise caused by vehicles running on it when the wheels crowded first one side and then the other; the sound can be best described as a shriek.

There were at one time about 124 miles of single track on this system laid with this rail, and there are now 96½ miles, while there have been laid 101½ miles of 9-in. side-bearing girder, weighing 94 lbs. to the

FIG. 13.

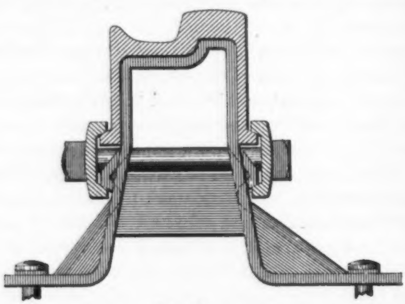

FIG. 14.

yard. The side-bearing girder is less objectionable in that less frequent repairs are required, but it breaks the surface of the pavement in a disagreeable way, and wagons tend to follow the rails and leave them with reluctance.

All the surface railroad companies in Brooklyn have been notified that no more rail of this type can be laid, and they have been requested to confer with each other, and submit designs for a standard section of a grooved rail or some form which will admit of the pavement on both sides of the rail being maintained at the same level.

The writer is of the opinion that in many cases there can be no reasonable objection to the use of a T-rail 7 or 9 ins. in depth. Kent Avenue, upon which are located large sugar refineries, sustains a very heavy traffic. Loaded trucks almost invariably travel with two wheels on the rails, while the other two soon cut a deep rut in the paving blocks about 15 ins. outside the outer rail, so that granite pavement

laid upon sand cannot be kept in passable condition for more than two years. The American Sugar Refining Company and the Brooklyn Heights Railroad Company offered this year to contribute one-half of the expense of laying a new granite pavement on a Portland cement concrete foundation. It would have seemed wise to defer this improvement until some form of rail should be adopted which would present no obstruction to wagons, and yet offer no inducements to them to follow it. One track, however, has been relaid, and one side of the street paved this year. The writer has suggested to the railroad company the adoption of the form of construction shown in Fig. 15. for the remaining track. The rail is a 9-in. T, weighing 78 lbs. per yard, should be in 60-ft. lengths, and laid with cast-welded joints. Tie bars at intervals of about 10 ft. would prevent spreading. The rail would undoubtedly last twice as long as that used in the other track, there would be almost no break in the surface of the pavement, and no obstruction to the passage of vehicles along or across it, while they could not follow it, and the traffic would be more evenly distributed over the entire paved surface. The blocks next to the rail would be set in cement mortar, and those on the inside would have the cor- Mr. Lewis.

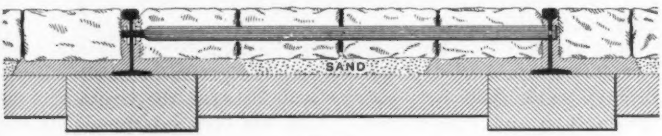

FIG. 15.

ners slightly chamfered off, giving room for the wheel flanges. While it may be almost impossible to keep a paving block from which the corner has been chipped in position along the inside of a side-bearing rail when every wheel turning out of the track has to mount the block, there is no reason why such blocks cannot be kept in position along the rail proposed, nor why the wear should be very great. A trial under these conditions would soon demonstrate the merits or defects of this form of construction.

There is little doubt but that such a rail laid in this manner would give very satisfactory results in connection with asphalt pavement. A street in Minneapolis upon which track was so laid was paved with asphalt carried close to the rails on both sides, and the flange groove was formed by running a heavily loaded car over it as soon as the asphalt had been laid and rolled. F. W. Cappelen, M. Am. Soc. C. E., states that the asphalt has not as yet wrinkled or disintegrated along the rail. The use of unsightly granite or other toothing is thus avoided, and the asphalt will be much less difficult to maintain than it is when laid along the side-bearing girder.

Mr. Lewis. The cast-welded joints above referred to can no longer be called an experiment. One railroad company in Brooklyn had about 1 600 of them made on new 9-in. girder rails, of which but one has failed in the six months of service to which they have been subject. The cost was $3 75 each. Another company had over 2 000 joints made on old 4½-in. girder rail, about 40 of which have broken. This method of making joints is undoubtedly more successful with new and deep rails than in the case of old and lighter ones.

For suburban lines and on macadamized streets and roads a T-rail laid on cross-ties will doubtless give good satisfaction, toothing of granite blocks being used along the rails on heavy grades to prevent the washing out of the macadam. Even though it should require more care to keep a stone pavement in repair along rails of this section, the resulting economy to the railroad company through the longer life of the rail would more than compensate them.

Good track construction is a question in which the railroad corporations and the municipality are both interested, so that it should not be very difficult of attainment. Not so with the maintenance of the pavement after the tracks have been built. The railroad companies will do no more than they are required, and nothing if they can avoid it. The conditions prevailing in any one city will be of more interest than general statements.

The charters held by the Brooklyn companies provide that they "shall at all times keep in good repair the pavement of the streets through which their rails may be laid, between the tracks and for three feet on each side thereof." This has been interpreted by the companies to mean that they shall restore the pavement to as good condition as it was in before the tracks were laid, but that when the sides of the street are relaid with a new pavement they cannot be asked to make a corresponding change in that part between their tracks.

The president of one of the principal systems in Brooklyn, upon applying for a permit to lay new rails upon one of the widest streets in the city, the sides of which had just been paved with granite without expense to his company, was told that he should in relaying the pavement substitute granite for cobblestone. He protested against being compelled to do so, and seriously gave as a reason that if the pavement between the tracks should be such as to attract travel to it there would be much greater danger of those using it being injured by his cars. The tracks were rebuilt and the cobblestones were relaid.

The Brooklyn charter in providing for the repaving of streets says: "That no street or avenue over or through which a railroad is operated shall be so repaved unless the owner or owners of the franchise of such railroad shall first contribute a just and reasonable portion of the expense thereof, to be determined by the Commissioner of City Works." This requirement has been generally ignored and many miles of granite

pavement have been laid upon railroad streets towards the expense of which the companies have contributed nothing. Within the last two years, however, they have done somewhat better. One company has contributed one-fourth of the entire expense of repaving five important thoroughfares. Two other companies declined to contribute anything, and after the work was completed suit was brought against them for the cost of that portion of the new pavement between their tracks and rails. It is needless to say that the suits have not yet come to trial. The local improvement law enacted in 1895 provides "that in all cases when a surface railroad is laid and operated through any such street, one-fourth of the cost of such repavement shall be assessed upon such railroad, and one-fourth thereof on the other property benefited within the district of assessment," the remaining half being paid by the city at large. One street has been repaved with granite, and one with asphalt under this law, and the assessment, being a lien upon the railroad, can be collected. This only provides for repaving where an assessment is laid upon private property for a portion of the cost. Upon streets where an assessment has once been laid for an improved Mr. Lewis.

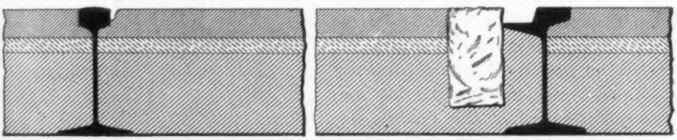

FIG. 16.

pavement the entire cost is paid by the city, and there is nothing but the charter provision calling for a contribution from the railroad companies, and that is so indefinite in its requirements that it amounts to but little.

With more perfect track construction and the use of a rail which will not be followed by vehicles, nearly all the traffic will follow the sides of the street and the pavement between the tracks will not require as frequent renewal as that outside. Much has been accomplished recently, however. The continuity of the asphalt pavement was broken by railroad crossings in a disagreeable manner, especially for drivers and wheelmen. At twenty-five such intersections the railroad companies have paid the cost of paving the entire spaces between their rails and tracks. The manner in which the pavement was laid along the rails is shown by Fig. 16, square cut granite blocks having been laid in Portland cement mortar along the inside of each rail, and the joints filled with grout. The blocks were set at the elevation of the tread of the rail. Pieces of granite of the same thickness and depth but 3 or 4 ft. long were used in several cases, but the results were not

Mr. Lewis. as good as when paving blocks 12 to 14 ins. in length were used. The result has been very satisfactory, and there is scarcely any perceptible shock in riding across them. On several streets where the sides are paved with asphalt and the track spaces with stone, the granite toothing has been removed by the railroad companies, and the asphalt carried directly up to the outside of the rail, greatly improving the appearance of the street. The suggestion that this should be done at the expense of the railroad companies, would, three years ago, have been ridiculed by them.

This problem must be solved under the authority of the laws as they exist at present, unless they can be modified. These are unsatisfactory, but notwithstanding this fact, if the whole matter could be placed in the hands of municipal engineers, who were unembarrassed by the consciousness or hope of a political future, and taken up by them with firmness and fairness towards the corporations, there would soon be a marked change for the better.

Mr. Pratt. MASON D. PRATT, Assoc. M. Am. Soc. C. E.—In studying the subject of the best form of rail and track construction for city streets where traffic is heavy, some aid may be had by looking carefully into the existing conditions, and seeing what effect the several sections of rail have had on the pavements as laid. This may lead to modifications of the sections which will tend to prevent any injurious effects.

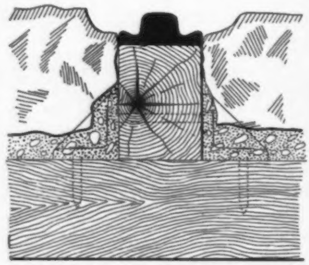

FIG. 17.

Fig. 17 shows the rail of the old horse-car tracks in New York City, which have by far the greatest mileage to-day. The time for their reconstruction is rapidly approaching, as New York is far behind all the other large cities in the matter of improved traction. The drawing very clearly shows the objectionable features mentioned by Mr. North, when the pavement is laid to line with the top surface of the rail. In many cases the pavements have gone down, and the entire head of the rail projects above the general street surface.

Fig. 18 is a partial section of the Broadway cable road. It is not peculiar to any one portion of the road, but fairly represents the conditions for the major part of its length. The paving blocks rest on a concrete bed, with but an inch of sand between, giving a practically unyielding bed. The illustration clearly shows the adhesion to an old practice in paving, where the foundation was not so well made and was of a more yielding nature; reference is made to the height of the paving blocks above the head of the rail. In pave-

ments, as ordinarily laid, it is expected that they will sink more or Mr. Pratt. less under the action of traffic and weather, and it was customary to set the stones $\frac{1}{2}$ in. or more above the rail. The wisdom of so doing was realized when the blocks did sink, often not stopping at the rail level. This will be found to be the case with many of the old tracks, like Fig. 17, which shows the pavement in its best condition. In the case of the Broadway road, and all others where there is a concrete base, the pavement has remained just where it was put, with the re-

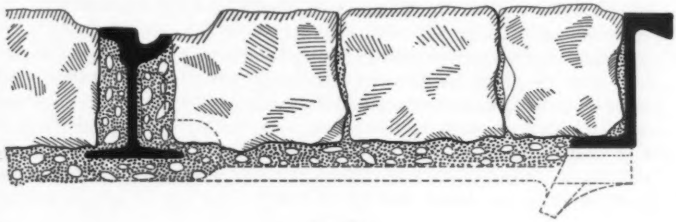

FIG. 18.

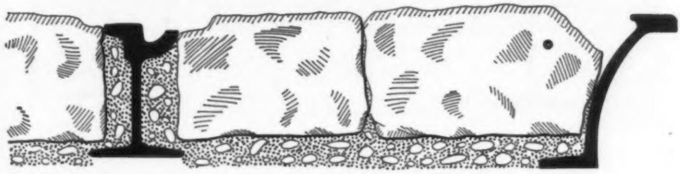

FIG. 19.

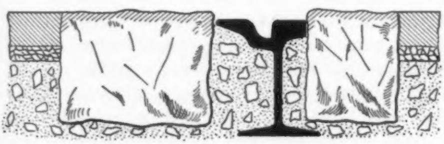

FIG. 20.

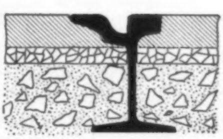

FIG. 21.

sult that there is a deep rut along each line of rails, the bottom of which is on a level with the rail head or tram. The same is true of the track of the Third Avenue cable road, Fig. 19, and will be so of the tracks now being laid in First Avenue in asphalt with granite toothing block, Fig. 20.

Fig. 21 shows part of a track laid with the improved rail mentioned by Mr. North, in asphalt pavement in One Hundred and Sixth Street. This is a very broad street, no cars have ever run on these

Mr. Pratt. tracks, and the street traffic is very light, so there is no guide as to what the results would have been under the conditions existing in most of the streets in the city.

Fig. 22 shows a part of a cable track in asphalt pavement in One Hundred and Sixteenth Street. The hollow on the inside of each track rail shows where the wear, due to vehicular traffic, has been concentrated.

It will be admitted, of course, that the most desirable condition for the surface of a street is one uninterrupted by ruts, grooves or other irregularities. It will also probably be admitted that the greatest life will be had from a pavement where the traffic is distributed over its entire surface, and that the pavement will suffer most when the traffic is concentrated along certain portions. The greatest damage is done to pavements by trucks and other heavy vehicles, and it is they that are constantly seeking the path of least resistance. This is, of course, along the rails, and where the rail is of such form that the tram, or guard portion, is lower than the head, no matter

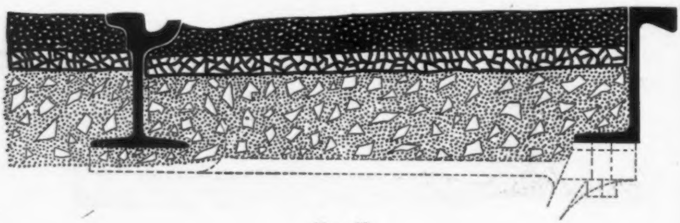

FIG. 22.

how little, there is a guiding shoulder which keeps the wheels in the tracks without any effort on the part of the driver. Comparatively few of the heavy trucks and drays have the same gauge of wheels as the railway tracks, but this in no way prevents their following the tracks, for one wheel will ride on the shelf of the rail, while the other follows a parallel path just outside the other rail. As there are many trucks of each class, it will be found that this concentration of wear has its effect in an appreciable trough along the outer rail and about 6 to 10 ins. away.

The same result will be had in the case of the improved form of rail, Fig. 23, where the pavement is laid as shown by Fig. 20.

The head of a perfect rail should be level, with a groove or flangeway only sufficiently large to pass the wheel flange freely, and of such shape that dirt, ice and similar obstructions will be easily worked out by the flanges themselves. The groove in the rail, Figs. 23, 24 and 25, does this admirably. Fig. 26 is the section of rail adopted in Washington, D. C., where all the streets are paved with asphalt and

Mr. Pratt.

kept clean. The wheel flanges are necessarily smaller than those in general use elsewhere.

There is one peculiar feature in the three sections just mentioned, namely, the extended lip on the tram. Just what use this serves it is difficult to see. It is possible that it had its origin in the idea that the immense traffic concentrated along the Broadway cable and other roads required a more substantial track than that offered by the lip of the rail in use on that road. This would be the case if it had been left at a lower elevation than the head, as, for instance, in the section shown in Fig. 24, but as before stated, it is for the good of the pavement that the street traffic be not invited to follow the track. When the rail head is level and the pavement laid flush with it, there is nothing to guide traffic along the tracks, and it will wander from the rail and distribute itself over more of the street surface. This being the case, there is no use whatever for a broad lip, which but adds so much more to the smooth steel surface for horses to slip on.

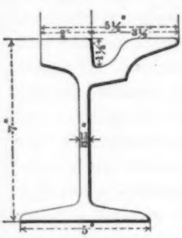

FIG. 23.

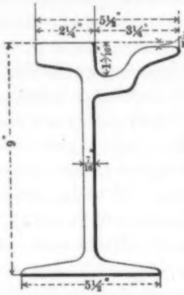

FIG. 24.

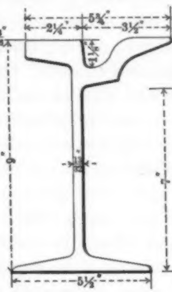

FIG. 25.

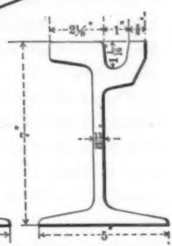

FIG. 26.

The Society was instrumental, a few years ago, in throwing considerable light on the question of standard rail sections for steam roads, and it is reasonable to think that a similar investigation into this subject may result in even more good to the street railways.

Mr. Waring.

GEORGE E. WARING, Esq.*—A calculation recently made, which may seem extravagant, although the facts will sustain it, shows that if all the streets in New York City of suitable grade were asphalted, and if all the street railway tracks were like that shown in Fig. 21, with no considerable space to receive dirt and make them difficult to sweep, the $1 200 000 now paid out annually for street sweeping alone would be reduced to $700 000. This shows that the City of New York could very well afford, at its own cost, to set aside all questions of the obligations of railroad companies, and reconstruct all city railways on which the tracks are not now what they should be.

* Commissioner of Street Cleaning, New York City.

Mr. Reed. W. Boardman Reed, Assoc. M. Am. Soc. C. E.—The subject of rails for street railways, and especially their influence on street pavements, is one that has received but little attention from engineers until within a few years; but the recent great increase in mileage of street railways, the growing demand for good roads, the fact that the weight of rolling stock can well be compared with that on steam roads, and the almost phenomenal increase of traffic on street car lines, makes it well worthy of attention.

Whether the prime object of the designers of the center-bearing or Hewitt rail was to keep trucks and other vehicles from following the tracks the speaker could not say, though that seems to be the generally accepted opinion. If so, it certainly failed to accomplish this result, for in New York, where there are more miles of center-bearing rail than of all other sections, drivers, especially when their wagons are heavily loaded, follow the track upon which this rail is laid as persistently as any other. Without doubt, however, this is the most desirable rail from a strictly railway standpoint; having a tram or flange on either side, dirt, slush or snow does not remain on the head, the car wheels themselves pushing such obstructions to either side and thus keeping it constantly clean. On account of the double tram, however, there is twice the annoyance to vehicular traffic that there is with almost any other section of rail. The pavement being set level with the head of the rail, a space is left on either side of the tread of the rail about 1½ ins. wide and of a depth equal to the distance from the head to the tram of the rail, about 1 in. Vehicles follow along on either side of the rail and soon wear the pavement away, so the space is increased to about 4 ins. in width or a little wider than the usual tire. The ram is so narrow that truck wheels do not ride it well, making the pavement wear more, and ruts are soon cut which are extremely dangerous.

The rail almost universally used throughout this country on street railways constructed or rebuilt within the past few years is the side-bearing rail, a section of which is shown in Fig. 4. It is a great improvement over the center-bearing rail so far as influence on street pavement is concerned. The pavement is laid next to the outside of the head and about level with it, so there is no rut ready made for vehicles to run in, and the pavement next to the outside of the rails does not wear much faster than any other portion of the street, thus reducing the cost of maintenance of the pavement nearly one-half, as compared with the cost with the center-bearing rail. On the inside of the rail there is a tram 3 ins. wide which carries the wheels of all vehicles having less than 3-in. tires. If the pavement in the track is laid level with the top of the tram, wheels of vehicles following the rails cut no rut and it is easier to turn out of the rails with a wagon than if the paving stones are left above it. It seems to have been

the universal custom, however, to keep the pavement, even in the track, level with the head of the rail, thus leaving a groove or rut similar to that found with center-bearing rails, except that the extra width of tram carries vehicles more easily and the pavement is simply worn back an inch or so on the edge and then rounded off, preventing dangerous ruts. Of course at intersecting streets where wagons cross the tracks at obtuse angles the pavement should be left level with the head of the rails to avoid the jolt that otherwise would occur. Mr. Reed.

The sections of rail shown in Figs. 2 and 5 have some advantages over the center-bearing and side-bearing rails for vehicular travel, but, like any grooved rail, are objectionable to railway companies on account of the difficulty of keeping the groove clean. The tram being bent up so that it is $\frac{5}{16}$ in. below the head, and the groove being but $1\frac{1}{4}$ ins. wide, it is much easier for vehicles to turn out of it than out of either of the previously mentioned sections. It has the same advantage as to pavement on the outside as the side-bearing rail, but it was found on Broadway, New York, that trucks following the rail soon wore a rut in the pavement next to the tram, and the cost of maintenance of pavement on this account was excessive. To remedy this evil, Mr. L. J. Hirt, formerly assistant chief engineer of the Metropolitan Traction Company, and the speaker decided it would be well to increase the width of the tram sufficiently to carry the trucks, and thus save this excessive wear on the pavement. A section was designed similar to that shown in Fig. 3, except the tram was $\frac{5}{16}$ in. below the head. The Department of Public Works, however, upon the recommendation of Mr. North, insisted that this tram be raised to the level of the head giving the section shown in Fig. 3. The raising of the tram makes it impossible to keep the dirt out of the groove by any scraper attached to a car, and it is possible to keep it clean only with hand scrapers and brooms. None of this section of rail has as yet been used to any extent in winter weather, but, judging from the amount of labor required to keep it clean under ordinary circumstances, it is feared it will be well nigh impossible to keep it free from snow and ice without a plentiful use of salt, which is condemned by the Boards of Health, Society for the Prevention of Cruelty to Animals, and on electric roads by the electricians. Of course, with cable or horse power a dirty rail is not as objectionable as it is with self-contained motor cars, and with the use of electric or compressed air this rail would cause much trouble, and still more trouble if the rails were used for a return circuit as on the trolley roads. Had the tram been left as originally designed, the trouble in this direction would be greatly lessened, and yet there would have been no appreciable difference to vehicular traffic. It is interesting in this connection to note the change recently made in the style of rails in England, where they have insisted, as some American authorities now insist, upon the head and tram being

Mr. Reed. the same height. Within a few months the authorities there have required the section to be changed so as to bring the tram below the head.

No section of rail has as yet been rolled suitable for steam railroad cars and locomotives for streets. Various methods, therefore, have been adopted to utilize the T-rail. The method used by the Central Railroad of New Jersey is a good one, but much too expensive for general use, and it necessitates the use of chairs 3½ or 4 ins. high, which make the structure weak. As the gauge of freight cars varies and the flanges are as much as 1½ ins. deep, it would be impossible to design a rail suitable for them that would not offer more or less impediment to vehicular traffic.

Stringer construction, so-called, is almost a thing of the past, and of but little interest except as a matter of history. The flat rail on timbers is not stable enough for modern cars, and in the few places where railroad companies have tried to use it with electric cars they have been confronted with snake heads, such as occurred in the early days of steam railroading.

This construction answers very well for horse-car traffic, and Mr. North's statement that the stringers soon rot and let the paving stones fall in is misleading. The writer has recently taken up stringers that have been down more than twenty years on a road where cars run on less than three minutes' headway; these stringers were badly decayed, but those fifteen years old were in a fair state of preservation, and certainly strong enough to hold up the pavement. Mr. North speaks of the joints on this style of construction. Where channel bars are used at the joints and care taken in boxing them into the timber, the joints stand up under heavy strain for some years. But little attention was formerly given to the joint, often nothing but a thin, flat iron being used, and on several miles of one of the most important lines in New York City there was not a single joint plate of any kind; it is no wonder that with such construction the joints went down, and made riding in either cars or wagons somewhat unpleasant.

With girder rails it is necessary, where paving blocks are set next to the rail, to use some kind of a filler between the upper and lower flanges. Creosoted wood, plain spruce plank, cement mortar and hard-burned terra-cotta bricks molded to fit the rail have been used. Until within the last two years, when the writer introduced the use of terra-cotta brick, mortar was used exclusively in New York. It answers the purpose as well as brick, but the cost of applying it, especially when cars are running over the rails during construction, is much greater than the brick. When asphalt pavement is laid against the rail, no filler is required.

Whenever two substances of different degrees of hardness are used next each other upon the surface of a street there is excessive wear at

their junction upon the softer, especially if they are joined together in a straight line. It is on this account that ruts are likely to be worn alongside the rails, and it is hard to see how increasing the width of the top of the rail to 18 or 20 ins., which would be the result of using the steel plate mentioned by Mr. North, would improve matters. If, however, the edge of this plate was toothed, thus giving the same result as granite toothing, it might answer equally as well as the stone, though even then the asphalt with which it is proposed to use this plate would probably show more wear than if stone was used. Mr. Reed.

As all heavy trucks are more than 4 ft. 8½-in. gauge, the standard gauge of street railroads, truck drivers follow one rail, thus throwing the opposite wheels about 18 ins. from the other rail. These outside wheels soon wear ruts in the hardest pavement and increase the cost of maintenance very much. To remedy this evil, the railroad companies in a number of cities, notably Philadelphia, Pa., Newark and, possibly, Jersey City, N. J., widened the gauge of their tracks, thus giving the heavy trucks metal tramways, but the trucks, once in the track, would not turn out, so the speed of cars was regulated by speed of trucks. Shortly after the introduction of electric cars, the gauge was brought to standard.

If the section of rail shown in Fig. 3 is used, and it is possible to maintain the pavement next to the rail level with it, trucks can not easily follow the rail and thus no such trouble as mentioned will arise, but as any pavement is softer than 0.55% to 0.65% carbon steel, which it is now proposed to use for street rails, the pavement will wear faster than the rail, and if originally laid flush with it, there will soon be more or less of a rut which vehicles will follow.

The speaker believes that granite or other stone pavement should be left ½ in. above the rail; the corners will soon round off so there will be no difficulty in turning out, the life of pavement will be very much increased, and the cost of maintenance much decreased.

The statement made as to the effect of the obligations imposed by the laws of the State of New York on street railroads is plainly erroneous, as the statute does not require the roads to pave and keep in repair, but only requires them to have and keep in repair. The obligations as read by some of the city officials having charge of street pavement would require the railroad companies to lay new pavement whenever these gentlemen thought that bicycle or buggy riding would be benefited by it.

The statement contained in the paper is unfair to the railroad companies, as it seeks to bring all of them within the obligation of repairing the pavement. There are many railroads in the city of New York and other cities of this country having charters that do not contain any obligation whatsoever as to street paving, while it has been held, particularly in a suit of the City of New York against the Eighth

Mr. Reed. Avenue Railroad Company, that the railroad was not under any obligation to lay new pavement in the street. The court, in this case, held specifically, that unless such an obligation was imposed by the charter of the company or some contract entered into by it with the city, that the city could not lay new pavement and charge the cost against the company.

Although it is well known that it takes a long time to secure justice in many cases, it is very evident that if the city had claims against railroad companies for street paving arising in the year 1889, and if the city authorities believed they had any claims against the railroad companies, the case would have been pushed to an issue before the present time.

The latter part of the paper contains a statement that the surface railroads have procured charters which do not require them to maintain the pavement, and that they claim that no additional burden can be laid on them. This is an erroneous position to take of the law. The position of the companies has always been that the legislature has not made any effort or sought in the slightest degree to impose the obligation of repair or the furnishing or relaying of new pavement upon them.

With regard to the weight of cars used on street surface railways, the following data may be useful:

Ordinary single-truck cars with 18-ft. to 20-ft. bodies, a $6\frac{1}{2}$-ft. to 7-ft. wheel base, equipped with two G. E. 800 motors, and having a seating capacity of about twenty-four, weigh from $7\frac{1}{2}$ to $8\frac{1}{2}$ tons. Double-truck cars with 35-ft. bodies, a wheel base on each truck of 5 ft., and a distance between truck centers of 18 ft., equipped with G. E. 1 200 motors, and having a seating capacity of from forty to fifty, weigh from 20 to 23 tons. The trucks of these cars are usually arranged to carry about 75% of the load on the drivers, which should be considered in calculating wear on rails. Cars such as are used on the Metropolitan Street Railway Company's cable and electric roads in New York City have single trucks, an 8-ft. wheel base, bodies 32 ft. long, and a seating capacity of twenty-eight; the cable cars weigh about 7 tons, and those equipped with G. E. motors about 9 tons.

A few words should be added in defence of some of the recent track construction in New York City. Within the past few years the railway companies have been looking forward to a change in motive power, by which they would be relieved of further annoyance with horses. What the new motive power would be could not be foretold. Wherever the cable or underground trolley has been adopted permanent construction on yokes has been carried out, but all other lines have been to a greater or less extent of a temporary character, with the idea that it was only a matter of a year or two when they would be

replaced by some other type. The track on One Hundred and Sixth Street* was built with a view to greater permanence than the rest, except those of the yoke construction. The rails are laid on cross-ties 5 ft. apart, which also serve as tie-rods, and rest on a beam of concrete from 6 to 8 ins. thick and 15 ins. wide. The concrete is built up around the base of the rails and holds them in place. Mr. Reed.

G. J. FIEBEGER, M. Am. Soc. C. E.—The construction of pavements along the street car tracks in the city of Washington is governed by the Act of Congress, June 11th, 1878, given below. Capt. Fiebeger.

The features to which attention is invited are the fifth, sixth and seventh paragraphs, which provide the means of keeping the pavements in repair, and of laying and relaying them if the railway company fails to comply with the provisions of the first paragraph.

The relaying of the old tracks with modern grooved girder rails was done in conformity to an Act of Congress of March 2d, 1889, also given below.

In carrying out the provisions of that act, the Commissioners, on the recommendation of the Engineer Department, adopted a rail with flange and head in the same horizontal plane and a groove 1 in. wide. This rail has given general satisfaction. Upon cable and underground trolley roads it is customary to pave the space between rails and tracks either with sheet asphalt or vitrified brick.

EXTRACTS FROM AN ACT PROVIDING A PERMANENT FORM OF GOVERNMENT FOR THE DISTRICT OF COLUMBIA.

* * * * * * * * *

The cost of laying down said pavements, sewers and other works, or of repairing the same, shall be paid for in the following proportions and manner, to wit: When any street or avenue through which a street railway runs shall be paved, such railway company shall bear all of the expense for that portion of the work lying between the exterior rails of the tracks of such roads, and for a distance of 2 ft. from and exterior to such track or tracks on each side thereof, and of keeping the same in repair.

But the said railway companies, having conformed to the grades established by the Commissioners, may use such cobblestone or Belgian blocks for paving their tracks, or the space between their tracks, as the Commissioners may direct.

The United States shall pay one-half of the cost of all work done under the provisions of this section, except that done by the railway companies, which payment shall be credited as part of the fifty per centum which the United States contributes toward the expenses of the District of Columbia for that year.

And all payments shall be made by the Secretary of the Treasury on the warrant or order of the Commissioners of the District of Columbia, or a majority thereof, in such amounts and at such times as they may deem safe and proper in view of the progress of the work.

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* Of which a partial cross-section is shown in Fig. 21.

Capt. Fiebeger. That if any street railway company shall neglect or refuse to perform the work required by this act, said pavement shall be laid between the tracks and exterior thereto of such railway by the District of Columbia.

And if such company shall fail or refuse to pay the sum due from them in respect of the work done by or under the orders of the proper officials of said District, in such case of the neglect or refusal of such railway company to perform the work required as aforesaid, the Commissioners of the District of Columbia shall issue certificates of indebtedness against the property, real or personal, of such railway company, which certificates shall bear interest at the rate of 10% per annum until paid, and which, until they are paid, shall remain and be a lien upon the property on or against which they are issued, together with the franchise of said company.

And if the said certificates are not paid within one year, the said Commissioners of the District of Columbia may proceed to sell the property against which they are issued, or so much thereof as may be necessary to pay the amount due, such sale to be first duly advertised daily for one week in some newspaper published in the city of Washington, and to be at public auction to the highest bidder.

When street railways cross any street or avenue, the pavement between the tracks of such railway shall conform to the pavement used upon such street or avenue, and the companies owning these intersecting railroads shall pay for such pavements in the same manner and proportion as required of other railway companies under the provisions of this section.

* * * * * * * * *

Approved June 11th, 1878.

DISTRICT OF COLUMBIA APPROPRIATION BILL, 1890.

* * * * * * * * *

That any company authorized by law to run cars propelled by horses in the District of Columbia is hereby authorized to substitute for horses electric power by storage or independent electrical batteries or underground wire, or underground cables moved by steam power, on the whole or any portion of its roadway, with authority to purchase and use any terminal grounds and facilities necessary for the purpose; and any such street railway electing to substitute such power on any part of its tracks or road-beds on the streets of the District of Columbia shall, before doing so, cause such part of its road-beds to be laid with a flat grooved rail, and made level with the surface of the streets upon each side of said tracks or road-beds, so that no obstruction shall be presented to vehicles passing over said tracks: *Provided*, That in the event said companies or either of them shall fail for the period of two years from the passage of this act to exercise the powers and privileges hereinbefore given, such companies are hereby required to cause said rails and roadbeds to be relaid with the flat grooved rail hereinbefore mentioned, so as to be level with the surface of the streets upon each side of said tracks or roadbeds and the cost of making the changes hereinbefore required shall be paid by the corporations or persons owning or operating said street railroads, and if, after being notified by the Commissioners of the District of Columbia in writing to comply with the terms of this act, the said corporations

or either of them shall not within ninety days thereafter begin the work required and complete the same within a reasonable time, not more than twelve months from the expiration of said period of ninety days, it shall be the duty of the Commissioners to cause the necessary changes in said rails and roadbeds to be made as soon as practicable; and shall issue certificates of indebtedness against the property, real or personal, of such railway company, which certificates shall bear interest at the rate of 10% per annum until paid, and which, until they are paid, shall remain and be a lien upon the property on or against which they are issued, together with the franchise of said company; and if the certificates are not paid within one year the said Commissioners of this District of Columbia may proceed to sell the property against which they were issued, or so much thereof as may be necessary to pay the amount due, such sale to be first duly advertised daily for one week in some newspaper published in the city of Washington, and to be sold at public auction to the highest bidder: *Provided further*, That after the passage of this act no other rail than that herein mentioned shall be laid by any street railway company in the streets of Washington and Georgetown, and all companies granted franchises or extensions by the Fiftieth Congress shall have extension of one year's time within which to lay their tracks. So much of the charters of the street railway companies of the District of Columbia as is inconsistent with this section is hereby repealed. *Provided further*, That the foregoing requirements as to motive power, rails and roadbeds shall not apply to street railroads outside the city of Georgetown and the boundary limits of the city of Washington; *and Provided*, That the authority hereinbefore granted in each and every particular shall be exercised only with the approval of the Commissioners of said District of Columbia, expressed by resolution of said board. Capt. Fiebeger

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Approved March 2d, 1889.

CORRESPONDENCE.

Mr. Whinery.

S. Whinery, M. Am. Soc. C. E.—While the subject of these two papers embraces only the relation between street railroad tracks and street pavements, it is rather difficult to separate it from the subject of construction of street railroads in general; but the writer will endeavor, in what he has to say, to confine himself to matter pertinent to the question. It seems necessary to say at the beginning, however, that the interests of the street railroad companies and of municipal authorities in charge of street pavement will be found in the near future to be more nearly identical than is generally recognized at present, and there ought to be harmonious action between them for the following reasons, which will be made the basis of this discussion:

First.—No pavement of any kind can be kept in good and proper condition along the rails of a street railroad unless the track construction is of such a character as to hold the rails rigidly in their position so as to avoid settlement, deflection or oscillation.

Second.—True economy on the part of the street railroad companies requires that their tracks shall be constructed in such a manner that the rails shall have sufficient strength not to deflect or vibrate and that the rails shall be so supported that they will not settle or yield under the loads passing over them.

The truth of the second proposition is forcing itself upon the managers of street railroads. Not a few of them are fully convinced that they cannot afford, as a matter of business, to construct their tracks in any but the most thorough and substantial manner. They have found that cheap and shabby track construction means excessive cost of maintenance of track. When their track is once constructed and a permanent pavement is laid over the street and along their rails, the expense of reaching and repairing the underground structure, raising low joints, tightening joint plates, and replacing the pavement, is so great that a large additional expenditure for a construction that shall be as nearly as possible permanent is more than justified.

Furthermore the wear and tear of cars and motors running over bad tracks is greatly increased. The writer knows of no statistics showing correctly the difference in cost of maintenance of cars and motors operated over poor track and track of the best construction, but from his own observation he believes it amounts to a sum that would pay a very large interest on the difference in cost between good and bad track construction. In view of these facts it is reasonable to expect that owners and managers of street railroads will, in the near future, be more than willing to adopt the very best and most permanent construction for their tracks. In fact, at this time, in many cities the street

railroad companies are voluntarily taking up track that a few years since was regarded as good enough for any street railroad, and replacing it with track of the very best modern construction. Mr. Whinery.

There is, as might be expected, a wide difference of opinion as to what constitutes the best track construction, and many companies are deferring the adoption of improved construction, not so much because they are unwilling to undertake such a construction, but because they are uncertain which of the many plans brought to their attention is the best. It is a fortunate circumstance that in the main the track construction which is best for the street railroad companies is also most favorable for laying and maintaining permanent street pavements along and among the tracks.

Coming now to the first proposition, it is idle to hope to keep street pavements in good condition along street railroad rails unless the rails are rigid and immovable in their place. This is the first condition of success; all other conditions are matters of detail.

In regard to the best section for the top of the rail, the writer does not believe that the section shown in Fig. 3 is the best yet used in this country. The principal objection to it is the sharp edge and unnecessary width of the flange. With a flange of that section, stone or other block pavements cannot be properly maintained along it. Even if the rail is immovable, many of the blocks are liable, upon slight depression, to drop below the edge of the flange as shown by dotted lines a in Fig. 27; and having imperfect lateral support, because it is very difficult to fill properly the space between the block and the web of the rail, the pavement soon becomes deranged. If, as is usually the case, the rail is not perfectly rigid and immovable, this danger becomes greatly aggravated. If the rail moves up and down under passing cars, the sharp edge of this flange is likely to engage with the rough surface of the block and to tend to move the block up and down with it.

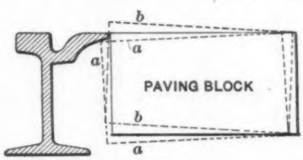

FIG. 27.

If firmly supported on its foundation, the block cannot move downward, but, when raised, particles of sand or street dirt drop under it and it cannot return to its original position. The action is repeated and in time many blocks may be brought to the position shown by the dotted lines b in Fig. 27, a condition often seen in brick or stone block pavement along the rails. In the case of sheet asphalt pavements laid directly against the rail, it is hardly possible to compress the asphalt under and against such a flange properly. If the rail vibrates, sand or street dirt will work between the asphalt and the bottom of the flange, and in time the surface of the flange becomes higher than the

Mr. Whinery. rail, which, as will be shown hereafter, is a condition unfavorable to the best service of the pavement. Furthermore, it may be said that the tendency of drivers to keep the wheels of their vehicles on and along the top of the rail is directly as the width of the rail top, and for this reason alone the top of the rail should be made as narrow as practicable.

A few years since Mr. H. J. Stanley, city engineer of Cincinnati, proposed, and the Cincinnati Street Railroad Company adopted, the section shown in Fig. 28 as a standard in that city. There are, in fact, two standard sections used, the only difference being that the rail used on asphalt-paved streets is 6 ins. high, while that used in granite-paved streets is 8 ins. high. In other respects they are identical. The writer believes that this is probably the best section of simple girder rail, from the pavement standpoint, yet adopted for streets. Its advantages are as follows:

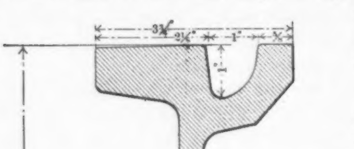

FIG. 28.

The rail is of the grooved pattern, with the flange rising to the same height as the tread. This is the only form of top that ought to be allowed on paved streets. The groove is made no wider than is absolutely necessary to accommodate the wheel flange. It is so narrow that only the narrowest vehicle wheels can possibly drop into it, and it is found in practice that very few wheels, indeed, get into the groove. In fact, with an asphalt pavement laid flush with the top of the rail, the track offers no obstruction whatever to the passage of vehicles, and in driving over the street, one would never know that there was a track in the street, except by seeing the tops of the rails. The sides of both tread and flange are vertical, which obviates the objections to the sharp-edged flange referred to above. This is especially important in the case of asphalt pavements, as a good strong support is secured for the asphalt against the rail. The flange of this rail has abundant strength and mass to withstand the weight and abrasion of travel. The top of the rail, both tread and flange, is joined to the vertical sides by a curve of very short radius, which renders it possible to make a good junction between the edge of the rail and asphalt pavement. Where the top and sides of the rail are joined by a curve of considerable radius, it is obviously impossible to make a good joint between the rail and the asphalt pavement. The top of the rails is as

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narrow as it is practicable to make it, consistent with necessary conditions. The strong and wide base and the general sturdy and substantial character of the section commend it to the favor of the track builder as well as to the paver.

In regard to the use of the common T-rail for street railroad track, opinions differ widely. At one time it was regarded as an abomination by paving engineers, municipal officers, and the people, and not without reason, as it was generally used. No one doubts that it offers more strength, stiffness and wearing capacity per square inch of section than any other form of rail in use, and is, therefore, the most economical rail to use from the street railroad company's point o view.

Some recent pavement constructions with this rail have proved very satisfactory, and indicate that where street railroad companies prefer its use, it may be made quite unobjectionable from the pavement

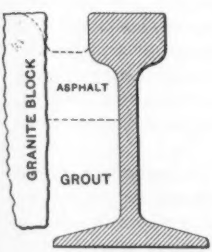

FIG. 29.

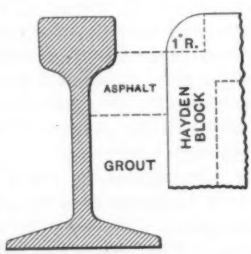

FIG. 30.

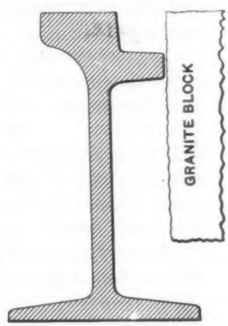

FIG. 31.

standpoint. Fig. 29 shows one construction of this character. The space for the wheel flange is formed by setting granite paving blocks at such a distance inside the rail as to leave sufficient flange space. This space should be made as narrow as possible, and should not exceed $1\frac{1}{8}$ ins. The granite blocks used should be specially dressed so as to present a nearly true face next the rail. They are set against a gauge, a strip of wood $1\frac{1}{8}$ ins. wide resting against the edge of the rail. The cavity between the rail and the blocks is filled to within $2\frac{1}{2}$ ins. of the top with good Portland cement grout, and the space above this is nearly filled with a special asphaltic preparation which renders the joint watertight. The consistency of this asphaltic preparation is such that in warm weather the wheel flange will impress itself into the material, forming a groove of such form and width as will accommodate the flanges. This construction offers far less obstruction to vehicular travel than any of the flanged rails like Fig. 4. Very

Mr. Whinery. few narrow wheels drop into the space between the rail and stone block, and as the groove is shallow, those that do so drop in are extricated without difficulty. In time the exposed corners of the blocks will become worn rounded as shown by the dotted line in Fig. 29, which renders it easier for wheels to leave the groove. There is little tendency of drivers to follow this rail, and consequently little difficulty from wheels getting into the groove.

A similar construction is shown in Fig. 30, where the block used is a brick block known as the Hayden block, with the corner next to the rail molded to a circle of 1 in. radius. Except that the block is not as durable as granite, this construction has proved very satisfactory.

Next to the full-grooved rail, like that previously referred to, this construction offers less obstruction to travel than any other the writer has observed. Where the T-rail is used, its sides should be vertical and the curve joining side and head should have a radius not exceeding $\frac{1}{8}$ in.

None of the rail sections like Figs. 4 and 10 should be tolerated on a paved street. In addition to the other objections their unstable equilibrium when the wheels of a heavy vehicle rest on the flange tends to turn them over and give them a lateral movement, which it is difficult to prevent, and will in time injure the adjoining pavement. A modified form of this section with the construction shown in Fig. 31, ought to give good results. If this construction has ever been used, it has not come to the writer's notice.

It has been generally thought that in laying an asphalt pavement along rails, it is necessary to interpose a line of paving blocks between the asphalt and the rails. It is best to do this where the rail is light and the track construction insecure. No matter what kind of pavement is used, or how it may be laid, it cannot be kept in fair order along the rails of an insecure and shaky track, and the use of the stone blocks lessens, but does not obviate, the difficulty of maintaining the pavement. Besides, people will fail to notice and will tolerate a bad condition of the stone blocks, while they would quickly note and comment on the ragged edge of an asphalt pavement.

Experience has proved that where the track construction is fairly stable, and rails of suitable top section are used, it is better in every way to lay the asphalt surface directly against the rail. It makes a better appearance, offers less obstruction to travel, and can be maintained at less expense than where the stone blocks are used.

It is true that the pavement along the rail will not be as durable as the body of the street, for the line of junction must be a line of weakness to some extent, but the abrasion of the asphalt which occurs will be narrow and can be repaired with more facility and less expense than in the case where stone liners are used.

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Where such stone liners are used, the old method of setting them as alternate headers and stretchers should not be followed. A simple line of blocks set end to end along the rail is better, as experience has shown. Where such stone liners are used, their utility will depend largely on the care with which they are set and held in place.

It is not unusual to see street railroad tracks, in which, for the want of suitable foundation and support, the rails have sunk to a depth of from $\frac{1}{2}$ to 2 ins. below the surface of the pavement, and the pavement has become loosened, broken and abraded along its exposed edge. Thoughtless people blame the pavement for the defects, and some cities where the pavements are guaranteed have attempted to hold the paving contractor responsible for the necessary repairs. This would seem to be so obviously unjust as to need no discussion, especially when it is remembered that to repair and adjust the pavement to the sunken track requires a change of grade of the surface of the pavement along the rails. The only adequate remedy in such cases is to reconstruct the track, and raise it to grade before the pavement repairs are attempted, and if the defective track construction has caused the disintegration of the pavement, the railroad company should be held for the cost of repairs.

The depth of the rail is a matter of importance in street pavement, where cross-ties are used. If a shallow rail is used so that stone or brick blocks rest upon, or nearly upon, the top of the cross-ties, the slight motion or tremor of the ties will be communicated to the pavement, and it will, in time, be injured. It is not unusual to see brick pavements between the rails so deranged by this cause that the location of every cross-tie is discernible in the pavement. There should be a space of at least 1 in., and at least 2 ins. is preferable, between the bottom of the paving blocks and the top of the cross-ties. In Cincinnati, where the depth of the granite paving blocks is from 6 to 7 ins., a rail having a depth of 8 ins. has been adopted as the standard for granite-paved streets. This has given excellent results, and the great stiffness of this deep section makes it a good one for the street railroad company also.

In laying asphalt pavement directly against rails, some care is necessary to secure good results. Especial care should be taken to compress the hot asphalt material thoroughly under and around the head and flange of the rail. In cold weather this cannot be properly done without first warming the rail, as otherwise the asphalt will be chilled when it comes in contact with the cold rail and cannot be properly compressed. The surface of the asphalt should be laid even with the top of the rail; if it is laid lower, the latter not only forms an obstruction to travel, but vehicle wheels will follow along the projecting rail and gradually wear a rut there; if it is laid higher than

Mr. Whinery. the top of the rail, the wheels of vehicles, and particularly the tread of broad car wheels, will abrade the edge of the pavement.

If a slight digression may be allowed, the writer would express the opinion that a revolution may be expected in the near future in the present methods of constructing street railroad tracks in paved streets. The coming track is one in which no cross-ties are used, unless that name be applied to small tie-rods placed at intervals to hold the rails from spreading. The rails will be deep and strong, with a base not less than 6 and probably 8 ins. wide. This rail will be laid carefully true to line and surface, on a longitudinal beam of Portland cement concrete, and embedded directly in the concrete foundation and surface of the street pavement. In time probably some form of box girder, with a rail top readily removable and replaceable will take the place of the present rail sections. The girder will have a wide base, and will rest upon a concrete beam, and when once in place will be as permanent as the pavement foundation itself. In at least four cities known to the writer, girder rails laid on a concrete foundation without cross-ties are now in use, and have, so far,

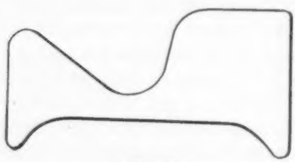

FIG. 32.

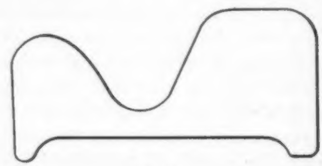

FIG. 33.

given excellent results. A track construction of this character, when perfected, will greatly simplify the problem of paving along or among street car rails.

Mr. Angerer. VICTOR ANGERER, Esq.—The early rails laid on street railways in this country were of a semi-grooved type, similar to the rails used in England, where railways for passenger transportation in city streets received somewhat earlier development, although the street railway was really an American invention Figs. 32, 33 and 34 show such rails laid on some of the first street railway lines in New York and other cities. Wagons and vehicles of all kinds soon commenced to take advantage of the smoother surface presented by these rails than by the street pavements of those times, and tried to follow them. The narrow tires, which partly entered these grooves without getting a flat bearing on any part of them, soon commenced to cut into the soft iron rails, and the deep groove also proved somewhat dangerous to the wheels. This led to the form of rail still known under the name of the "Philadelphia tram rail," first used on the Fifth and Sixth Streets line in that city, which gave a broad flat wagon-way, or tram as it was called,

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from which it derived its name. At the same time, the gauge of the track in the city of Philadelphia and in other places where this rail was introduced, was widened, as it had been found that the standard English gauge of 4 ft. 8½ ins. did not allow two horses, which were universally used, to travel abreast between the rails without danger of stepping and slipping on the rails. This type of rail also had some disadvantages from a railway standpoint which were discovered in the earlier forms of rails, in that it showed a tendency to tilt outward under the load, and, further, that the head of the rail was usually covered with mud and dust, without any possibility of the wheels themselves cleaning this accumulation away. The usual T-rails on steam railroads and lines outside of city streets did not show such a tendency, which led to the introduction of a rail approximating the T-rail and adaptable for city streets, and to the usual construction of a flat rail on wooden stringers. This approximation of the T-rail, really a T-rail lowered so that the head came down on the base without the intervention of any web, has since been known as the center-

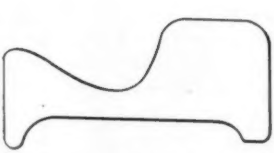

FIG. 34.

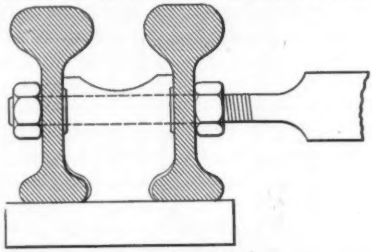

FIG. 35.

bearing rail, it giving, as the name indicates, a central bearing of the wheel on the rail, and of the rail on the stringer, *i. e.*, a better distribution of the load on its supports. Further advantages claimed for it were that the head cleaned itself from mud and ice, and it gave two lines of spikes instead of one as on the other rails, and reversibility, that is, when one side has worn away from the action of the wheels, it could be turned round to give further use, although advantage was rarely taken of the last feature. Incidentally, it also did away with at least some of the necessity for widening the gauge, as the difference between the metallic surfaces was widened by the difference of the width of the usual tram on the other rails and the small spiking flange on the center-bearing rail.

This, in short, is the writer's understanding of the development of the top surfaces of street railway rails in this country. The center-bearing rail undoubtedly presented many advantages to the railway company, not the least of which was the fact that it was much more difficult for wagons to follow this rail than the former shapes, although

Mr. Angerer. they still continued, at least they attempted, to follow it wherever its surface held out an advantage over the surface of the pavement. The objections to this form of rail, its bad influence on the pavement through the obstructions it offers to vehicular traffic, are well known. The unsightliness and disadvantages of these rails became more and more apparent as the pavements and the methods of laying the pavements improved. It was just ten years ago that the public in various places, and especially in New York City, waged war against the center-bearing rail, which ultimately led to its condemnation, although there is still a large amount of center-bearing rail in the streets of the city of New York, while in other places it has almost disappeared.

It was then that the matter of the use of a rail with narrow grooves similar to the rails used in England and on the European continent was largely advocated, and some French systems particularly were taken as models. These are illustrated in Figs. 35 and 36. Much was written and said at that time as to the practicability of the use of such

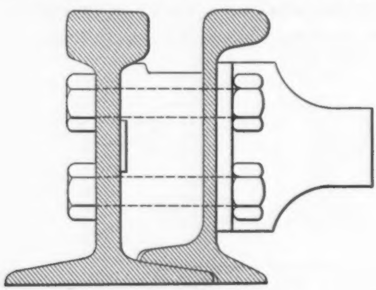

FIG. 36.

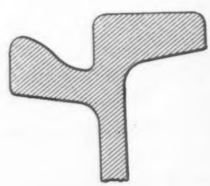

FIG. 37.

a rail in American cities. By the grooved rail at that time was always understood what is now called a rail with a flush or full groove, that is, the guard or tram part of the same height as the head. The main objection raised against these rails was, at that time at least, that only in the very rare cases of the principal streets in the principal cities was the pavement in such condition that drivers would not wish to follow the smooth surfaces of the rails, and as there was nothing to guide them on the flat and narrow surface of the full-grooved rail, they would continually slide off on one side or the other, and soon cut ruts alongside of the rail; and, as a second objection, that the grooves could not be kept free from dirt or ice in winter except at very great expense, due to the wagons running on the track and sweeping the dirt into the grooves, and on account of the greater severity of the climate than in those parts of Europe where full-grooved rails are in more universal use. Both assertions were proved to be facts by pieces of track laid with flush-grooved rails in several cities, some with rails directly im-

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ported from England, and some with similar rails rolled in this country. It was then that the half-grooved rails were suggested, and the so-called Richards rail of that type and some other rails were laid extensively throughout the following years in various cities, and in fact the rails laid on the Broadway and Third Avenue cable roads (Figs. 2 and 5) are representatives of this type of rail. The idea was that the tram or guard part, not coming up to the full height of the head, would give some guidance to the wagon wheels, and, further, that the reduced depth of the groove would allow it to clean itself more readily by the action of the wheel flanges. Both objects were defeated, at least to some extent, first, in that the surface presented to the wagon wheels was too small and therefore quickly worn away, and consequently wear was thrown on the adjoining paving stones by the wider tires, and, further, that the groove did not clean itself, especially from ice and snow in winter, owing more particularly to the lines of the sides of the groove, which were too steep. Some other rails were designed with grooves of different shapes, approximating the half groove, but with rounding sides, as in Fig. 37. These cleared themselves of dirt to some extent, but not sufficiently, and they further developed the curious difficulty that even on very slight curves the flanges of the wheels showed a tendency to run up on top of the rounded side and cause the car to leave the track. This, however, could have been obviated by making the groove somewhat wider. All these later rails were of the girder type, the girder rails having in the meantime largely replaced the old flat rails on stringers, which, however, had nothing to do with the top surface.

It is but natural to ask why a full-grooved rail should not be used in this country as it is in London, Paris and other foreign cities, since American pavements have attained the same degree of excellence, and the principal objection is thereby removed. The conditions, however, are different. In the cities mentioned, street railways are, as a rule, banished from narrow streets. They are generally given the privilege only on wide streets where there is plenty of room for other traffic, and, besides, the streets are not as much obstructed by teams standing along the curb loading and unloading in front of warehouses and stores, as they are in great commercial cities in this country, all this work being done more or less in back streets and large court yards, while here the street railway track and very little room on both sides of it offers very often the only unobstructed passage-way for vehicles and wagons in the street. Many of the wide avenues in New York are obstructed by elevated railroad posts, cut up into three strips, so to speak; the two nearest to the curbs are rarely clear for vehicular traffic, and the central one is occupied by two tracks on which the wagons are more or less compelled to run. On other avenues in New York and in other cities there are four railway tracks running parallel, occupying practically

Mr. Angerer. the entire width of even the wide streets. The drivers, even if they wanted to, cannot, in most cases, avoid these tracks. They do not wish to overlap them, as that brings the smooth surfaces of the rails under their horses' hoofs, causing them to slip, and, in consequence, if for no other reason, they will follow the track as much as the track will permit. If a rail with a flush top surface like the English grooved rails is used, two ruts alongside of each rail will soon appear. If a rail is used that gives a guide to the wagon wheels, and at the same time gives a width of surface for the wheels to run on equal to the most prevalent width of tire, these ruts will be avoided, and the only marked lines of wear on the pavement will be on both sides of the track, produced by those wagons which are of wider gauge than the track. It is the writer's opinion that the last-named wear on the pavement is less serious than the ruts alongside the flush-grooved rail. It may be said that in Washington the flush-grooved rail has come into extensive and successful use, but the conditions there are markedly different from those of commercial and industrial cities, the streets are wide and unobstructed, and the traffic light. It will also be observed that the flanges on the car wheels used in Washington are much smaller than the flanges used elsewhere; the narrow groove of the rails will not permit larger flanges. The railway companies, especially those using mechanical traction, object to these small wheel flanges, not as a matter of economy, because the wheels wear out faster, but as a matter of safety.

Street railways now extend into the suburbs of the cities, and the suburban traffic has to be brought into the heart of the cities. The cars which run on the suburban lines also have to run on the tracks in the city proper, but in these suburbs the speed demanded is much greater, and the greater speed demands larger flanges on the wheels for safety. The rail of the Metropolitan Traction Company, Fig. 3, gives the necessary width and depth of groove for such flanges, but it will be seen that it will allow the narrow tires of light buggies to drop quite deep in the groove, below the part of the side rounded off, so that turning out must throw quite a heavy strain on the light wheels. Slightly wider tires up to about $1\frac{1}{2}$ ins. in width sink into the groove, when new, just far enough to be guided, but they run only on one edge, and the tendency would be to wear the groove wider and the sides steeper. Wide tires, on account of the tram being carried to a level with the head, have no guide, and are free to slide off to both sides, and produce the wear on the pavement mentioned. The extra width of the tram for this reason does no particular good. If the tram was lowered, say at least $\frac{1}{4}$ in. below the head, it would accomplish its object in guiding and providing a surface for the wagons. This lowering would also permit the side of the groove to be made still more flaring, thereby facilitating the turning out of the very narrow tires and

increasing the chances of the groove clearing itself from dirt and ice; Mr. Angerer. it does not do it now, in fact it is said that some difficulty has been experienced with cars running off on account of ice in the groove.

Without going into the details of increased frictional and electrical resistance, it must be admitted that a tolerably clean rail is essential for the practical operation of surface railways, and unless the rail is so shaped that there are good chances of it being kept clean by the action of the wheels themselves, it will have to be kept clean by other means. Scrapers and brushes attached to the car necessarily have to be of a somewhat flexible nature so as not to catch in irregularities or at joints, and are therefore not sure to remove packed and frozen dirt and ice. The use of salt would, of course, help this somewhat, but this is universally objected to by the authorities and the public. Men with hand scrapers to walk along the track and clean the groove in accordance with European practice would have to be resorted to, but this would be found hardly practicable, aside from the question of expense, in some of our busy streets. In view of the desirability of a clean rail head, the bevel on the back of the head of the rail shown in Fig. 10, which has been called one of the vices of this rail, would be one of its virtues from a railway standpoint, and the writer cannot understand the serious objection raised against it. This beveled extension of the head, however, has been put on not solely for the purpose of allowing the wheels to clean off the dirt towards the outside, but also to provide for a wider tread on the wheel, without having it strike some projecting paving stone. In the writer's opinion, wider treads on the wheels are quite certain to become one of the requirements of the street railways, owing to the suburban lines above referred to, and, further, to lessen the severity of wear of the heavy motor cars on frogs and switches. If the life of the latter could thereby be lengthened, and the disturbance of the pavement around them, due to their comparatively frequent replacements, be minimized, it would be one advantage gained from the paving side of the question. With this bevel added on the outside of the head of the rail of the Metropolitan Traction Company, but with the tram lowered, as shown in Fig. 38, and the corner at the gauge line of this rail rounded off a little more,

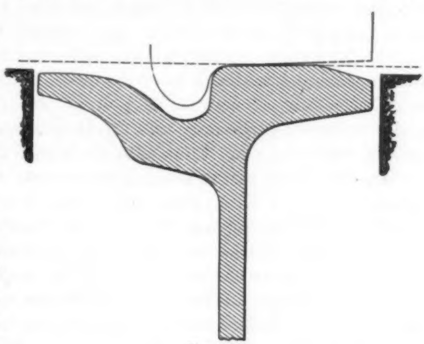

FIG. 38.

Mr. Angerer. the resulting section might prove the right form for the best paved streets. The writer's plan would be to carry the pavement not quite up to the level of the head, which would give a practically even surface all over the street with very little obstruction to the crossing of vehicles by the slightly projecting heads, and at the same time provide for some of the necessities pointed out in regard to the wagon traffic running longitudinally with the tracks. Where the pavement is not laid with such nicety as to level, and is not of such a character that it would keep to such level, the writer is inclined to think that a top similar to the old Philadelphia tram rail is probably the most useful. On curves, especially on sharp curves, a guard rail with the guard projecting above the head with a groove sufficiently wide to allow for the skewed position of the wheels will, of course, have to be used to insure the safety of the cars on curves.

As to the type of rail, it is hardly probable a railway company can be found to-day which is willing to put down the old flat rail on stringers in preference to the girder type, except for repairs in some old tracks. The more permanent and solid character of the girder rail construction also makes it more desirable in its relation to the pavement, provided, of course, as pointed out by Mr. North, that the spaces underneath the head and the tram are properly filled with some material before paving, when stones are used for the entire pavement, or alongside of the rail in asphalt pavements. As to the height of the girder rails, or, in other words, the depth to which the ties should be buried beneath the surface of the street, it certainly should be as much as 9 ins. where blocks are used. In asphalt pavements where the asphalt is carried to the rail, and in brick or similar pavements, 7 ins. or even 6 ins. might answer. Mr. North has well pointed out the relative value of the different kinds of pavement when laid alongside of a rail, and how they should be laid.

As to the suggestion of an iron plate laid alongside of the rail, it would only prevent the ruts from forming if it was made very wide, so that the wagons would not be apt to leave it; but such a wide metal surface in the street would in itself be objectionable, would be difficult to keep down, and would quickly wear out if made as thin as described.

As to the rails for steam railway cars and locomotives in city streets, the devices described are certainly among the best, but on account of the absolutely necessary depth and width of the grooves, it is doubtful whether any rail for this purpose can be devised which would not be objectionable and destructive to the pavement in city streets. Fortunately, the steam railway track in paved city streets is on the wane.

Mr. Price. W. G. PRICE, M. Am. Soc. C. E.—Since the introduction of electric traction there has been a great increase in the number of flat wheels

produced on street cars. This is due to the increased speed at which the cars are run, and to the increase of weight on each wheel, which has been more than doubled. When light trail cars are hauled by electric motor cars it is seldom that a flat wheel is made on the trailer, and but few flat wheels are produced on the light cable cars. The wheel is flattened by sliding it on a dry or sanded rail. When the bearing surface of the rail is level, and the tread of the wheel is conical or beveled, as in Fig. 39, the contact between the wheel and the rail is a mere point; when the wheel slides the metal of the wheel is heated and softened at this point and is easily abraded so as to produce a flat Mr. Price.

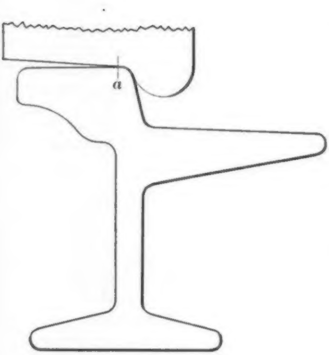

Fig. 39.

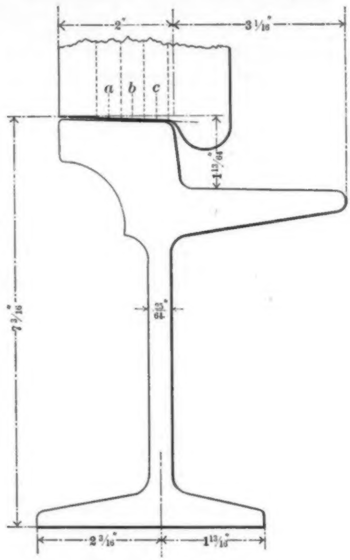

Fig. 40.

spot. By changing the form of the rail to that shown in Fig. 40, which is beveled to fit the conical wheel tread, a much larger surface of the wheel will be in contact with the rail, and it will require a much greater weight to produce abrasion when it slides.

This form of rail has been adopted by the Chicago City Railway Company, and is proving to be very satisfactory. Old rails are found to be worn to this shape, which has been done at the expense of much abnormal wear to the wheels. When the rail is beveled, the wheels retain the beveled tread, which is necessary to enable a lagging wheel to catch up without slipping on a straight track. The bevel of the wheel

Mr. Price. is of very little benefit on street railway curves, owing to their short radius. Figs. 40 and 41 show sections of rails now in use on the State Street cable line, the height of the head being $1\frac{3}{16}$ ins. It is beveled to conform to the bevel of the car wheel for two-thirds of its width from the gauge line across the head. There is probably a slight slipping of the wheels on the rails due to the unequal diameters of the wheel at the points of contact. The point *c* will travel faster than than *b*, and *a* will travel slower than *b*. The waste of power due to this slipping is very slight, for considering the coefficient of friction as 0.15, it will be found that for a load of 1 ton at a speed of 10 miles per hour, the energy consumed to produce this slipping is 0.0104 H.-P. The experience of the Chicago City Railway Company has been that the beveled rail saves wear of both rails and wheels, increasing their life by about 35 per cent. Fig. 42 shows a section of a new and old car

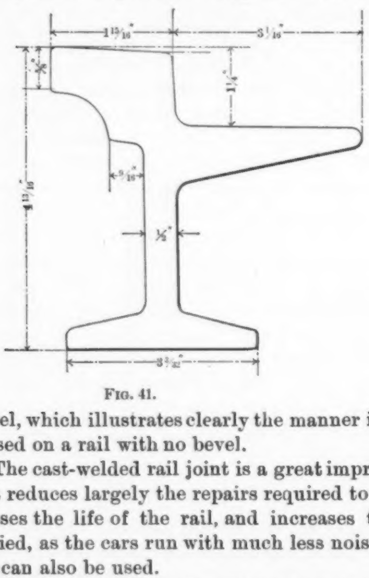

FIG. 41.

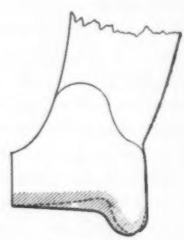

FIG 42.

wheel, which illustrates clearly the manner in which the tread will wear if used on a rail with no bevel.

The cast-welded rail joint is a great improvement over old methods, as it reduces largely the repairs required to track and cars, greatly increases the life of the rail, and increases the number of passengers carried, as the cars run with much less noise and vibration. A lighter rail can also be used.

Mr. M. K. Bowen, Superintendent of the Chicago City Railway Company, has made the following statements:*

"Seventeen thousand joints were put in during the year 1895, and of these only 154 joints were lost. The joint in comparative tests has been shown to be far stronger than the rail itself, and such breakages as have occurred were due to a flaw in the metal. The metal cast around the joint has eight times the cross-section area of the rail. Hence,

* In a paper presented to the American Street Railway Association, October 20th, 1896.

considering steel as four times as strong as cast iron, the joint is twice as strong as the rail. It has been found in some cases where this joint was used at crossings with other tracks, that the tracks were apt to be pulled out of shape through the changes of temperature. To overcome this, the joint nearest the crossing should be anchored in a substantial manner. The method of making the joint is as follows: The rails at the joint are scraped and brightened, a cast-iron mold is placed around the joint, making a tight fit. Into this the molten iron, 25% scrap, 25% soft, and 50% hard silicon pig iron, is poured; the metal in contact with the mold begins to cool and form a crust while the interior remains molten. This crust continues to cool, and at the same time contracts, forcing the molten metal strongly toward the center, which makes a solid and rigid joint. The top, or bearing part of the ball of the rail is afterwards filed off perfectly level, so that it is very difficult to detect a joint by riding over it or looking for it. Upon breaking a joint which has been cast-welded, three spots will usually be found where amalgamation has taken place between the rail and cast portion, one on each side of the web of the rail and the other on the bottom. These spots are from 1½ to 2 ins. in diameter. There has been some discussion as to its being a bond for carrying electric current. I cannot recommend it with certainty, as there are occasional joints which I have taken off where no amalgamation has taken place whatsoever, thus destroying the effect as a bond of all joints in that line of track. To overcome this difficulty I have adopted the plan of bonding all joints. However, further experiments and care in the casting of joints may develop their efficiency as a bond." Mr. Price.

The question as to what condition a track should be allowed to deteriorate before beginning repairs is a very important one. There is a point of time in the life of the track at which money expended in repairs will be most efficient. Mr. Bowen says on this subject:

"The task of solving this question was brought before me not long ago concerning the State Street cable track, which had reached a deplorable condition. I had run over the line a car weighing 8 665 lbs., attached behind a grip-car by means of a recording spring balance called a dynamometer. This test car was then run over a track newly made at the same speed as over the old line; the dynamometer showed that it took 13.75 lbs. more pull per ton to haul cars over the old line that over the new. The average speed of cars on this street is 12 miles per hour. The excess horse-power required to haul 1 ton was 0.44, and the excess cost of hauling 1 ton one hour was $0.0088. The number of tons hauled 1 mile per year on this track was 45 147 537, and the time required to haul 1 ton 1 mile was five minutes; and 45 147 537 tons hauled at a given speed for five minutes is equal in work done to 3 762 295 tons hauled at the same speed for one hour; 3 762 295 multiplied by $0.0088 equals $33 108, which is the excess cost per year for hauling cars on account of bad track. It is estimated that the new track with cast joints will last twelve years, and as there will be no low joints the drawbar pull will not increase much until the rail is worn down sufficiently to allow the wheel to run on the flange, so the annual saving will be nearly $33 108, during the life of the rail, and the total saving will be $397 276, which in twelve years will pay principal and interest on $293 444, which is the amount we could profitably expend in repairs. The actual cost of rebuilding this track was $61 670."

Mr. Price. It is evident that if this track had been repaired at a much earlier date, a considerable amount of money that was used in buying coal and repairing rolling stock could have been added to the dividends.

Mr. Jennings. W. T. JENNINGS, M. Am. Soc. C. E.—Toronto has now about 80 miles of track, yielding $64 000 per annum for track mileage rental.

A clause in the condition of the sale of the street railway franchise, dated May 5th, 1891, reads as follows:

"The city will construct, reconstruct and maintain in repair the street railway portion of the roadways, viz., for double track 16 ft. 6 ins., and for single track 8 ft. 8 ins., on all streets traversed by the railway system, but not the tracks and substructure required for the said railways."

The railway company pays to the city treasury the sum of $800 per annum per mile of single track, sidings and turn-outs not being counted as track mileage, and also pays the following percentages:

On gross receipts up to $1 000 000 per annum, 8%
" " " between $1 000 000 and $1 500 000 per annum, 10%
" " " " $1 500 000 and $2 000 000, 12%
" " " " $2 000 000 and $3 000 000, 15%
over $3 000 000.............. 20%

The annual receipts in 1886 were about $1 000 000.

The company is to maintain the track in a state of thorough efficiency, and remove, renew or replace it, as the city engineer may direct. The specifications provide that cars are not to be overcrowded; a comfortable number of passengers for each class of cars is to be determined by the city engineer and approved by the city counsel. Cars are to have right of way, and vehicles or persons are not to obstruct or delay their operation.

Mr. Cushing. E. B. CUSHING, M. Am. Soc. C. E.—In connection with the subject of more permanent methods in street railway construction, and the consequent less frequent disturbance of pavements, it would be profitable to consider the preservation of timber used in such construction. There is quite a variation in the life of ties of the same kind of timber. In an instance which came under the writer's notice, the best of a lot of ties used in construction lasted nearly twice as long as those which first failed, although of the same timber. When the wood began to rot, some part of the line was thus disturbed yearly for tie renewals. Unless the conditions are such that the beds of the ties are generally dry, those methods of preservation in which mineral salts are used will probably not be satisfactory, as such salts are easily soluble in water. The use of dead oil of coal tar, creosote, would without doubt be economical. Sap pine, *Pinus mitis*, suitable for creosoting, can be purchased in southern markets at from $1 to $4 less per 1 000 ft. B. M. than the heart pine. Ties of this timber treated with 12 to 14 lbs. dead oil per cubic foot could probably be obtained for 60 to 80 cents each, f. o. b., at any creosote works situated convenient to timber

supply. Such ties would last from 18 to 25 years. While it is desirable to have timber treated at regular creosoting works in order that the best results be obtained, the writer believes that should transportation charges render this impracticable, a street railway company having extensive mileage could construct at its power house, at reasonable cost, an apparatus for boiling seasoned timber in the oil, and that the interest on the cost of such a plant would be more than saved in the annual timber renewals. Creosote does not permeate to the center of the timber, but forms a black ring an inch or so in thickness, thus excluding the elements of decay. Where it becomes necessary to trim or cut the timber after treatment, it is important to apply hot creosote with a brush to the place cut, and where track is regauged, the hot liquid should be poured into old spike holes. The neglect of this simple matter has caused failure of creosoted timber that would otherwise have lasted many years. Mr. Cushing.

Horace Andrews, M. Am. Soc. C. E.—In Albany the side-bearing rail was prescribed by the common council in 1885, and as the old center-bearing rails wore out, they were replaced by side-bearing rails of the general shape, on the wearing surface, of Fig. 4. A 9-in. girder rail, similar to Fig. 4 in all respects, is the latest pattern, adopted after numerous trials of different forms. On asphalt-paved streets granite blocks were laid, alternate headers and stretchers, and the general surface of the asphalt between the rails was kept at the level of the top of the rail. Owing, as the writer believes, to the insufficient and improper foundation of the rails, the blocks were shaken loose at many places, and the railway company has taken them up. In replacing the asphalt its surface has been kept level with the inside flange of the rail, thus increasing the difficulty of crossing the track. Whether ruts will form in the asphalt adjacent to the rails remains to be seen. Last summer brick pavement was laid on an avenue where there was about 6 500 ft. of double track. The writer urged the railway company to dispense with wooden ties or sleepers, instancing the practice in Toronto, where it is stated the result from laying the rails directly on Portland cement concrete has been quite satisfactory. The company believed its interests would be secured by the use of wooden ties, however, and used these, spaced about 2 ft. between centers. Fortunately in this instance, the first in the city, concrete was laid below the ties to a depth of 6 ins., and the railway company filled between and over the ties to within about 6 ins. of the surface of the pavement, with concrete. Molded bricks were used to fit under the flanges of the rail, a different pattern being required on each side. Mr Andrews.

In Albany the expense of new pavements may be assessed "among all the houses and lots, vacant lots and franchises intended to be benefited." Until 1891 the expense to be borne by the street railways was

Mr. Andrews. defined by law as that for work, labor and materials required to pave between the rails at each track, and no more. This has been amended so as to leave the assessment discretionary, as above noted.

Large assessments have been paid by the railway company, as almost every street where tracks are laid has been repaved with granite, asphalt or brick within the past ten years. The benefit accruing to the railway company from the repaving of a street may appear slight, but, when a side-bearing rail is employed, a good pavement tends to divert the traffic from the rails, which are otherwise the pleasantest and most used part of the street, and thus the company gains an incidental benefit.

There are four matters suggested by the papers on which further information is to be desired:

First.—Can the form of rail shown in Fig. 3 be used in connection with Fig. 4 with car wheels of ordinary pattern?

Second.—If a concrete base is to support the rail, without ties, is not a 6-in. girder rail with a wide bottom flange better than a 9-in. girder rail, especially with brick or asphalt pavements?

Third.—With a good block or brick pavement cannot the rails be preserved to correct gauge without the use of cross-rods at frequent intervals? The writer has seen a brick-paved street where these rods were entirely omitted, yet the gauge was well maintained. The rods are much in the way when paving with blocks or brick. With bricks especially they interfere sadly with correct alignment.

Fourth.—What is the best position for the wires making the electric bond between rails? It would seem easier to pave between the rails with the bond on the flange and not on the web of the rail.

Mr. Tratman. E. E. Russell Tratman, Assoc. M. Am. Soc. C. E.—It is unfortunate that there should exist such inharmonious relations between the street railway companies and the municipal authorities, by which the public has to suffer. The streets are laid out and maintained for the accommodation of the public, and the street railway is simply allowed to use them in affording better accommodation and more rapid means of transportation for those who care to pay for such increased facilities. It has, of course, certain rights, including a right of way for its cars, but it has no right to interfere with the use of the street by the public at large. If the company's charter requires the company to do its share of the paving, means should be taken to enforce compliance with this requirement. If there is no such provision, then it is the duty of the city to see that the street is properly paved and maintained. The experience at Washington has shown that railway companies can be held in control in respect to this matter, and there is no good reason why this should not be done in cities having the ordinary form of municipal government. One actual reason, but not a good one, is the bad system of organization of such government

in many cities, and its control by politicians for party and personal interests rather than public interests. Without good governing bodies it is useless to expect good government, good streets or good administration of affairs. Mr. Tratman.

As to the special tracks for steam railway traffic on city streets, while there may be cases where such construction is still necessary, it should be emphatically stated that at this time a paved street is no place for a steam railway to occupy.

O. H. TRIPP, Assoc. M. Am. Soc. C. E.—In 1892 a street railway company began operations in Rockland, Me., and received permission to use a T-rail. The main street through the center of the town is paved with granite blocks on gravel with gravel joints, and for some distance to the north of this paving the space between the rails and 1½ ft. outside is also paved. The city paid for the blocks, and the company did the work. Through the portion of the street paved, the track is in the center of the street; where the track is on the side, no paving whatever was done. The track is of 50-lb. T-rails, and where there is a pavement it is on cast-iron chairs to admit the depth of the paving blocks. The ties are about 5 ins. deep by 6 ins. wide and 7 ft. long. The consequences of this construction are just what any one familiar with such tracks would readily foresee. The groove inside the rail is such that there is constant danger of crippling the wheels of any light carriage caught in it, unless great care is taken, and in many places the outside rut is nearly as bad. Several lessons may be learned from such an experiment. Among them, speaking more especially of small towns, would seem to be: Mr. Tripp.

First.—The advice of an expert should be asked before granting any right of way, and the whole structure, by constant, careful inspection, should be made to correspond to his instructions.

Second.—The company should be rigidly bound to keep the part of the street occupied by it in complete repair at all times and under all circumstances, so as to offer the least possible interference with usual traffic of the street.

EDWIN MITCHELL, Assoc. M. Am. Soc. C. E.—The ideally perfect railway track on a paved street would be one that does not interfere with other traffic on the street, while properly fulfilling its purpose as a railway. To approach this perfection two conditions must be fulfilled; the rail must make the least possible break in the evenness of the street surface, and the construction and material must be of such strength and durability as to cause the least possible necessity for repairs. That there is little track which begins to approach these conditions is not surprising, considering the quick growth of rapid transit systems. Ten years ago nearly all street cars were light horse cars drawn at a rate seldom exceeding six miles an hour. Now there are electric cars with as much as 5 tons on a single axle running at Mr. Mitchell.

Mr. Mitchell. rates of 15 and even 20 miles an hour. This development, of course, could not be foreseen in the first days of rapid transit in cities, and there were very insufficient provisions in regard to methods of construction in nearly all of the franchises first given. That many of the franchises granted in more recent years are little better in their provisions in regard to manner of construction and maintenance of the streets is a fact reflecting great discredit on the bodies disposing of such valuable privileges. The majority of the recent franchises have contained provisions of greater or less stringency in regard to maintenance of the paving about their tracks. There are instances where an enlightened management has been alive to the fact that their own interests consisted in the best possible construction, but the attainment of good construction must usually be accomplished by municipal regulations.

It is interesting, in this connection, to see what has been accomplished in those cities which have the most satisfactory street railway

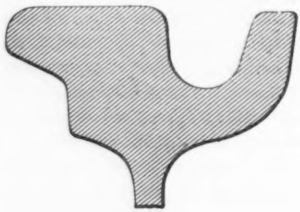

FIG. 43.

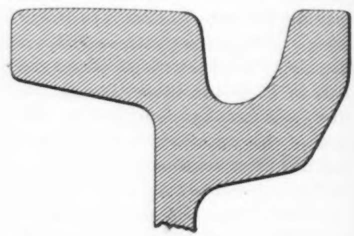

FIG. 44.

tracks. In Washington street railway building has proceeded under much stricter regulations and with better results as regard track and foundation than in any other city of which the writer has knowledge. Fig. 43 shows the head of the rail, adopted by the Washington and Georgetown Railroad Company, now the Capital Traction Company, for their cable lines. This is an 80-lb. rail, 6 ins. high, with a 6-in. base. Fig. 44 shows the head of the rail adopted by the Metropolitan Railroad Company for their underground electric lines. This is an 83-lb. rail, $6\frac{1}{8}$ ins. high, with a $4\frac{7}{8}$-in. base. The Columbia cable road has a rail almost the same as that of the Capital Traction Company. It can readily be seen that no ordinary wheel tires can slip into these grooves. The roads mentioned, having a central conduit, cannot make use of cross-tie construction. Fig. 45 is a cross-section of the road-bed of the Capital Traction Company. The cross-section of the Columbia Railway Company is similar, except in the paving. The latter company, however, has the yokes spaced 5 ft. apart, while the

other lines have 4½-ft. intervals. The underground electric lines differ in having a shallower conduit and yoke. In these roads there is no material to decay, and with a perfect joint they would be as near everlasting as could be devised. Mr. Mitchell.

The joints of the Capital Traction Company are light four-bolt angle bars, which have sunk and given a great deal of trouble. A number of cast-welded joints have been put in during the past year as an experiment. The tracks of the Columbia and of the Metropolitan roads, which have been built more recently, have heavy six-bolt angle-bar joints, and they have given little trouble, as yet. From an extensive experience with steam railroad track, however, the writer believes that there is no form of splice joint supporting only the head of the rail which will maintain a good surface for any great length of time; and he believes this to be even more true of street railway track where the joints are out of sight, and constant vigilance cannot be exercised for loose bolts.

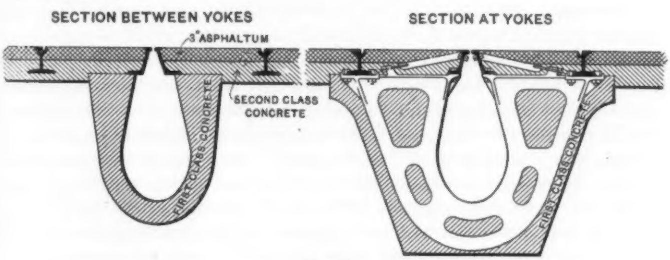

Fig. 45.

On the lines of the Capital Traction Company and the Metropolitan Railroad Company, the asphalt has been laid up to the rails and is cracked and broken in many places. On the Columbia Railway vitrified brick have been used between the rails with a toothing course of brick on the outside, and the adjoining asphalt is well keyed and is preserved in good condition. The horse-car lines in Washington have a grooved rail, as ordained by Congress, laid on cross-ties with a cobble or block pavement between the rails.

For a track with a firm pavement and pavement foundation on both sides of its rails and where all portions of it cannot be examined at frequent intervals and loose ties secured and low places raised by tamping, a longitudinal system of supports giving a continuous bearing seems to the writer to be the logical method of construction. One advantage of this in laying the track is that it is necessary to excavate to the full depth of the track foundation for only a narrow space beneath the rails. In Detroit, where a new railway was put down in a well-paved street, only sufficient pavement was taken up to excavate a

Mr. Mitchell. trench for the concrete stringers and to put the tie-rods in place. All perishable material should be avoided. The only instances where such track construction has been adopted—a rail laid directly on a longitudinal concrete support—of which the writer can obtain knowledge, are in the cities of Montreal, Toronto, Detroit, Minneapolis and St. Paul, and in all of these places the method seems to have given a satisfactory track.

From a study of what has been accomplished so far, the best track for rapid transit railways in a paved street would seem to be a rail similar to those in use in Washington, made 8 ins. high, however, if granite or asphalt block paving is used, laid on a concrete stringer or a flat metallic stringer, bedded in concrete, with tie-rods at 6-ft. intervals, with a strong base-supporting joint, preferably a welded joint if the difficulty with broken rails is not too great. If the track is in an asphalt-paved street, toothing courses of brick will make the smoothest and best bond for the asphalt at the sides of the rail.

Mr. Plimpton. ARTHUR L. PLIMPTON, M. Am. Soc. C. E.—In speaking of the condition of things where the municipality keeps the whole pavement in repair and collects from the company the cost of the latter's part between tracks, Mr. Owen says: "This might work satisfactorily if one point did not come up to create trouble. It is the one point that is going to make endless friction and is the unconsidered element, viz., the repairing and renewing of the track itself." The author here certainly touches upon what is already proving to be and will be more and more in the near future the greatest difficulty of all, for up to the present time the best street railroad track known on which a large number of cars are operated will give out long before the pavement needs renewing, provided the latter consists of granite blocks laid on a concrete foundation at the time the track was built. Mr. Owen refers to the practice of maintenance of track on steam railroads, and does not seem to appreciate the real reason why similar methods are not followed on even the best managed street railroads, but the writer will state that it is a vastly different matter keeping track in good condition on a street railroad from what it is on a steam road, where the location is owned and entirely under the control of the company, and every bolt and nut is in sight. A steam railroad roadmaster told the writer that he let the street crossings go as long as possible without repairs, as it was so difficult to get at the tracks at such places. On the street railroad it is all like the street crossing of the steam road, it is all in the street. It is absolutely impossible to do anything in the way of setting up bolts to a track as now generally built without the removal of and therefore permanent injury to the pavement. Hence the early attempts that were made to introduce boxes at the joints, which would allow access to the bolts and nuts by removal of an iron cover in the surface of the street, but these did not prove to be satisfactory and have been

Mr. Plimpton.

given up. In short, the difficulty and expense of watching and keeping the fastenings tightened up is so great that no attempt is really made to do it until the track has fallen into bad shape.

Street railroad companies have by no means been idle, but have been striving all the time to build a track in such manner as to require practically no repairs; notably, such improvements as making frogs and switches of solid construction instead of in separate parts bolted together, making the frog centers and the parts of the switches that would ordinarily wear out first of specially hardened steel, making a steam railroad crossing one solid structure throughout, laying the track on a concrete foundation, making the rails themselves of harder steel, the use of 60-ft. rails instead of 30-ft., and the welding of the joints of the track itself. These are all in the line of a longer life for the track and really seem to be the only direction in which to work to help the problem.

With regard to the ideal track on Beacon Street in Brookline, where the tracks are on a reservation 20 ft. wide all grassed over, it has proved to be a great mistake, as was predicted in advance, to try to raise grass on a railroad track, for not only is it impossible to maintain the track at a good surface owing to the loam working down into the gravel bed, but the life of the ties is shortened and in winter the freezing of the loam causes an upheaval of the surface so great in places that it has to be trimmed off in order to allow the cars to pass over without scraping, thus defeating the very object of having it a grass reservation.

In the writer's judgment, if, after being properly tamped, the track should be covered with pebbles or beach gravel to a depth of 1 or 2 ins. over the ties, and then if the space between the tracks and the space on each side between the reservation and the roadway be made nicely kept grass areas, even if they should be not more than 2 ft. wide, surely the railroad company could maintain the tracks in much better condition, and their appearance would be better than the present so-called grassed area with its numerous bare spots. Setting aside the exact way the tracks shall be built, the idea of a reservation is in itself a most excellent one, as it affords an opportunity to run cars at much greater speed with far less liability to accident.

Mr. Wilson.

G. L. Wilson, M. Am. Soc. C. E.—In 1895 the City of St. Paul repaved several streets upon which there were street car tracks with sheet asphalt, the street car company being obliged by the common council under the terms of its charter to lay the same pavement on the space occupied by its tracks. This was done with the ordinary track construction, the rails laid on wooden ties, to which they were spiked, and, after lining and surfacing the track, a 6-in. concrete foundation was put in around and between the ties and the paving laid, leaving the track simply imbedded in the paving, but with no solid foundation under the ties. With the heavy electric cars now

Mr. Wilson. operated it was found that the vibration of the track under traffic, especially with an asphalt pavement, was sufficient to destroy the adjacent surface rapidly. In 1896 an attempt was made by the Twin City Rapid Transit Company, which operates the street railways in both St. Paul and Minneapolis, to put down a permanent and solid track and then to have the pavement laid so as to make a solid construction, as nearly as might be. With this object in view, after investigating the methods in use in Toronto and Montreal, it was decided to adopt an 80-lb. rail of the section recommended by the rail committee of the American Society of Civil Engineers, in 60-ft. lengths with Falk cast joints and connected with tie-rods $\frac{7}{16}$ x 2 ins., spaced 12 ft. Under each rail is a beam of Portland cement concrete 8 x 15 ins. in section. The concrete under rails and paving is carried along as nearly as practicable at the same time in order that both pavement and track may rest on a solid floor. While this has been used but a short time on about 6 miles of track, it has given such satisfaction that it is believed this method of street railway construction is a partial solution of the problem of how to build permanent track in paved streets.

In the writer's opinion, two changes are necessary. The rail must be increased to a depth of 6 ins. and a grooved head used. The cost as described above is approximately, per mile of double track, according to figures furnished by the street railway company, as follows:

Cost of track laying	$5 200
Cost of joints	1 000
Cost of concrete beam	5 300
Cost of rails and tie-rods	8 500
Track alone	$20 000
Asphalt paving, strip 18 ft. wide—$2 53, 10-year guaranty	26 717
Track and paving	$46 717

Mr. Cappelen. F. W. Cappelen, M. Am. Soc. C. E.—On ordinary railroads the entire line is practically constantly patrolled, so that bed and track can be kept in as good a condition as the management desires. Low joints are readily raised, bad ties easily exchanged for good ones, bolts tightened, etc., as every thing is in plain view to the men in charge. The conditions are entirely different on a street railway. After the track is down nothing is visible but the top or running surface of the rail, and when a joint sags it means the ripping up of the pavement of the street at that point to bring the track to proper alignment and grade. The same is the case when removal of ties or rails becomes necessary. In addition to the cost of properly caring for the track itself comes the cost of repairing the pavement between the tracks, it

being taken for granted that the corporation owning the street railway will at least care and pay for the pavement in the space from the outside rail on a double-track road. The repair bills of a street railway system operated with horses were comparatively small, although the track construction was generally poor. The cable roads made far better track construction an absolute necessity, and companies that attempted and are attempting light and poor track construction for electric street railways have found or will find that the expense for maintenance of track is a big item. Mr. Cappelen.

The city of Minneapolis was one of the first in the United States in which the horse railway system was changed into an electric system, the entire change of 100 miles being made in a year. The company did not, however, change track and rail very much, but used a great amount of 4-in. light rail, 45 and 54 lbs. per yard. The Johnson 78-lb. girder rail was also used, and after considerable wrangling, the city council permitted the company to use the Shanghai 6-in. 70-lb. T-rail on some new extensions.

As most of the streets were paved with 6-in. cedar block on 2-in. foundation plank, much trouble was experienced with the pavement next to the rails and between them. The ties had to be cut down or 4-in. blocks used. With the 6-in. T-rail, strips of wood were placed along the rail to form the groove for the flanges of the car wheels to run in. The rails were spiked to pine ties on 2 ft. centers and almost anything used for ballast. In many cases cobble stones were used between rails. The city charter, however, provides that the space between rails must be paved with the same material as the balance of the street, but the city council would occasionally grant the company the right to do differently. After a while asphalt was ordered on certain streets, and the street railway company was obliged to look at the matter of track construction in a little different way; it finally received permission to pave between rails and tracks with granite, and the city put granite toothing on the outside of the rail. The 6-in. 78-lb. Johnson girder rail was used, but no particular care was taken in the ballasting of the tracks, and the result was, of course, that it settled and the asphalt broke away after a short period.

This year several principal down-town streets were ordered paved, and the writer was delighted to learn that the street railway company would do everything in its power to construct a first-class track in every respect. For all crossings and curve work, the so-called Johnson guaranty work was used. All switches and frogs have removable Harveyized steel pieces, and it is expected that this work will stand in the worst places at least nine years. The life of the old frogs, etc., did not exceed five years, and they were generally pretty bad after two years' wear. Ties were used for this part of the track; they were set in concrete and the entire intersection and cross-overs were paved with

Mr. Cappelen. fine-cut granite set in cement mortar with the joints filled with cement. For all straight track work, 60-ft. T-rails were used. The rail is the 80-lb. section recommended by a committee of the Society. Three methods of constructing the track were followed, each being an improvement upon the former, at least according to the ideas of the writer and the company.

The same company owns the street railway system in Minneapolis and St. Paul, and the work was commenced in St. Paul somewhat earlier than in Minneapolis. The first plan adopted there was as follows:

After the sub-foundation had been thoroughly rammed or rolled, the necessary slight excavation was made for a concrete beam to run longitudinally under the rail. This beam was $8\frac{1}{2}$ ins. in depth, 15 ins. wide, and constructed so that the top surface would be at the proper grade to receive the base of the rail. The beam was formed between boards. The concrete used consisted of one part Portland cement, two and one-half parts of sand, and four and one-half parts of crushed rock. Upon the beams, after they had set, the rails were placed and tied together every 10 ft. with 2 x $\frac{3}{8}$-in. tie-rods set on edge, as shown in Fig. 46.

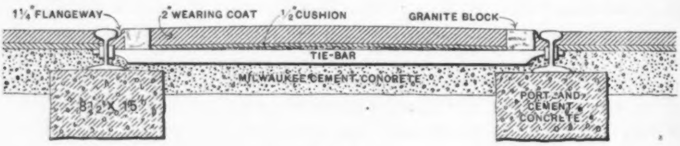

FIG. 46.

After the rails were lined up, the joints were welded, room being left in the concrete every 60 ft. for the joints. The street railway company experimented last winter with the so-called Falk cast-welded joints and adopted them for all the future work. The joint is made in the following manner:

The rails where the joint is to be made are first thoroughly cleaned with files and emery paper. Cast-iron molds are then placed around the joint, and held in place with clamp screws both horizontally and vertically. It was found necessary to have a heavy vertical screw to prevent the joint from heaving on account of the expansion due to the heat. After the molds were placed, the molten metal was poured and the joints thus completed. After cooling, the molds were removed and any rough edges left trimmed off. The joint is made so that a flangeway is formed in the cast. The company owns two of the so-called cast-welding machines. The cost of each is about \$2 500, and its capacity 8 500 lbs. per cast. The joint for the 80-lb. rails requires about 138 lbs. of metal, and the cost, per joint, is about \$2. This includes the cost of fixing the rails for the joint. A 45-lb. rail requires

102 lbs. for a joint, and a 54-rail requires 115 lbs. A mixture of half pig and half castings' scrap gives the best results. The furnace is loaded in layers, beginning with wood, coke and pig, coke, pig, etc. Mr. Cappelen.

After the joints were made, Milwaukee cement concrete, 6 ins. in thickness, composed of one part of cement to two and one-half parts of sand, and four and one-half to five parts of rock, was placed to proper grade to receive 2½ ins. of asphalt pavement across the entire street and between the rails and tracks, leaving enough space on the inside of the rails to lay granite blocks 4½ ins. deep, 3½ ins. wide, and 9 ins. long. These blocks were, however, set simultaneously with and in the concrete, being separated from the head of the rail by 1¼-in. wooden strip, so as to form the flangeway for the car wheels. After the strip was removed, the lower 2½ ins. of the space left was filled with cement grout, and the upper 2½ ins. to the top of the rail was filled with asphaltic cement consisting of about 30% asphalt and the balance limestone dust. This mixture remains soft enough to form the proper groove when the first car is run over the track. The joints between the granite blocks were filled with asphaltic cement. After the track work was completed, as described, the asphalt pavement proper was put down.

Considerable trouble was experienced in St. Paul with the rails after the joints had been cast. In a little while about 1 500 ft. of track looked like a snake, and it was very difficult to get it back in line; in fact the superintendent of the street railway company thought he would be obliged to cut the rails, which, however, did not prove necessary.

When the work came up in Minneapolis, this matter was discussed, and it was thought advisable to proceed in a different way. Ties were placed 6 to 8 ft. apart, and the rails were lined up and temporarily fastened to the ties; then the cast-iron joints were made, and the concrete beam put in between ties in the same manner as in the first case. The ties were then pulled out, the space filled, and the balance of the street concreted and completed as before. The rails were also spiked to the concrete beam as soon as it was in place. The track was kept in perfect alignment in this way. After discussing the work as it progressed, a further modification in constructing the beam was adopted. As it was not always possible to follow with the concrete work of the street proper as fast as the beam was built, a good bond was not obtained between the beam and the other concrete, so the method was changed. The ordinary concrete was put down outside and inside the rails, forming a rough groove about 8 ins. deep, 15 ins. wide at the bottom and 18 to 20 ins. at the top. In this groove, as soon as it was built, the beam concrete was placed, otherwise the construction was as in the second case.

The cost per foot of rail for the beam construction only, including grading, was 26 cents in the first and second cases, and 27 cents in the

Mr. Cappelen. third. The filler cost about 5 cents per foot. The cost of putting down temporary ties and laying, lining and surfacing 1 mile of single track preparatory to putting in the concrete beam, including labor and material used in welding the joints, was approximately $850.

In connection with this change of track construction, the writer changed the cross-sections of the streets as well as the intersections where repaving was done. All the old streets have very deep gutters, from 12 to 15 ins., and even more. This made it necessary at intersections to use aprons over the gutters at the corners, making them unsightly. The gutters were easily filled under the aprons, and too much space in the street was lost. Wherever repaving has been done, this was changed, so that now the gutters are only 6 to 8 ins. in depth, with the corners of the streets rounded off to a 12-ft. radius and the street raised at the corner, so that a step to the pavement of from 4 to 5 ins. only is needed.

Drainage is taken care of by putting in double catch basins. This makes beautiful intersections and pleases everybody. On a 50-ft. roadway paved with asphalt and without tracks, 8-in. gutters and 10-in. crowns are used; with tracks, 8-in. gutters and 7-in. crowns from the rail.

The cost per mile of double track constructed as related would be about as follows:

Cost of putting down temporary ties and laying, lining, surfacing, joints, etc., of a double track	$1 700
Beam work, etc	6 968
Rails and tie-bars *	9 400
Asphalt paving at $2 43 per square yard, ten-year guaranty	15 840
Total, per mile	$33 908

This is a very heavy expense, and it is sincerely hoped that the construction will prove satisfactory. About 2½ miles have been completed this season in Minneapolis. Brick was used on one street with the same track construction. In place of the granite blocks a special grooved brick fitting under the head of the rail was used.

So far as the writer knows, this construction has only been employed elsewhere in Montreal and Toronto, but without the cast-welded joint. The writer suggested to the company that a different rail be used, but as the season was too far advanced when the streets were finally ordered repaved, the company claimed that a different rail could not be obtained. The writer would suggest that the rail shown in Fig. 3 be used, but with a 6-in. base instead of one of 5 ins. This would give a better bearing on the concrete beam, and permit the use of deeper granite blocks, which, also, would be placed in staggered position.

* 60-ft. rails cost $2 a ton more than 30-ft. rails.

There hardly seems to be any necessity for a 9-in. rail, particularly if a track construction like that just described is used. Some trouble is anticipated with the flange groove as built in Minneapolis, but as several main streets with an electric railway have a width of 64 ft. between curb lines, a very small percentage of the travel utilizes the car tracks, and in no case is the roadway less than 50 ft., which leaves a double-team track on each side of the car tracks. Mr. Cappelen.

Mr. Owen mentions as an ideal road with trolley tracks, Beacon Street, Brookline, Mass. Minneapolis boasts of a road where the arrangement is different, and certainly the whole makes a beautiful appearance. This road is Hennepin Avenue Boulevard, with a 66-ft. roadway between curb lines. The trolley tracks are in the center occupying 18.5 ft., separated from the rest of the street by curbs 6 ins. high. At street intersections the curbing disappears. The space between center curbs is sodded. The cross-section is shown in Fig. 47.

This road is not a business street, but one of the parkways used largely by pleasure carriages and bicycles. The trolley cars run very fast and at short intervals during the summer months.

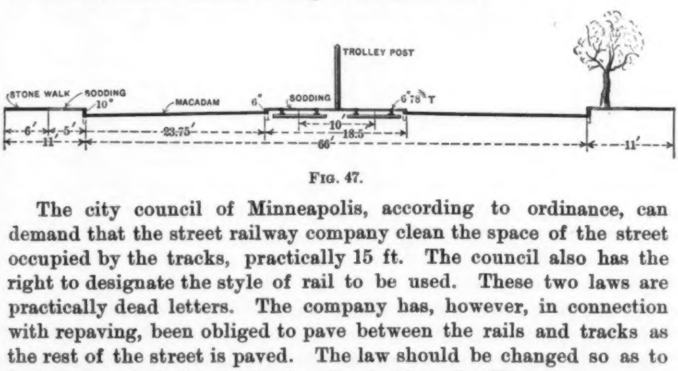

FIG. 47.

The city council of Minneapolis, according to ordinance, can demand that the street railway company clean the space of the street occupied by the tracks, practically 15 ft. The council also has the right to designate the style of rail to be used. These two laws are practically dead letters. The company has, however, in connection with repaving, been obliged to pave between the rails and tracks as the rest of the street is paved. The law should be changed so as to include a space 2 ft. outside of each outside rail. There are no penalty clauses in the ordinances, so the only way to enforce the latter, if it came to a fight, would be to declare the company's franchise forfeited, which can be done legally. The writer also thinks that the entire track construction should be according to standard to be approved by the proper municipal authority.

WALTER KATTÉ, M. Am. Soc. C. E.—The writer does not care to offer any opinion with regard to the various types of rails for ordinary street railroads further than to remark that he certainly thinks the section shown in Fig. 3 decidedly the best of all those shown and eminently suited for use for standard steam roads. Fig. 48 shows a preliminary sketch of the general features of an adaptation of this sec- Mr Katté.

Mr. Katté. tion of rail to such purposes as would be required on standard gauge steam railroads for the heaviest class of locomotive traction. The broken lines give the outline of the Crimmins rail.

There are two points which Mr. North has overlooked in his discussion of the subject. The two greatest difficulties encountered in devising details of track for this purpose are :

First.—The ever-prevalent liability of worn flanges on locomotive driving wheels, technically known as hollow tire or false flange.

Second.—The minimum of gauge established by the Master Car Builders' Association between the inside of wheel flanges, which has been fixed at 4 ft. 5 ins.

The first of these causes, that is, hollow tire, is the reason of the $1\frac{9}{32}$ in. depth of flange groove referred to as being "unnecessarily great," in which the author is in error, for with hollow tire, it is not unnecessarily great, in fact, it is hardly deep enough. The answer to

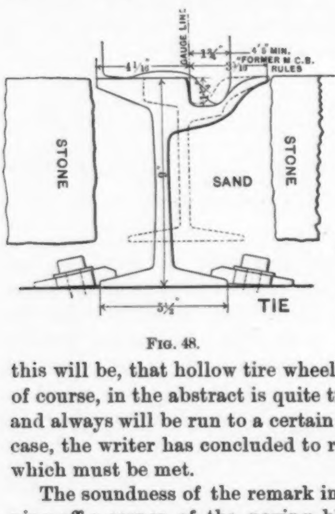

FIG. 48.

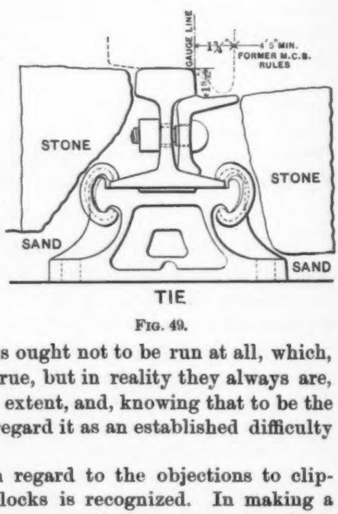

FIG. 49.

this will be, that hollow tire wheels ought not to be run at all, which, of course, in the abstract is quite true, but in reality they always are, and always will be run to a certain extent, and, knowing that to be the case, the writer has concluded to regard it as an established difficulty which must be met.

The soundness of the remark in regard to the objections to clipping off a corner of the paving blocks is recognized. In making a design, therefore, for a rail to meet these difficulties, the writer threw out a lip on one side far enough to carry false flanges, and on the other side has made the groove just wide enough to take in the minimum, back to back, wheel gauge, and with an extreme width to admit of easy placing of paving blocks without the chipping objected to. The girder rail shown in Fig. 48 figures up about 160 lbs. to the yard, but with some refinement in its lines it can be brought down to 150 lbs. without in any way compromising necessary strength.

The writer can hardly endorse Mr. North's opinion concerning the crossing made by the New Jersey Central Company. He does not regard it as very good for three reasons; first, it is clumsy looking and difficult to make; second, it is very uneconomical in its use of material, and hence, very expensive; and third, it takes no account of hollow tires. Mr. Katté.

It has been roughly estimated that the probable cost of such a track as is shown in Fig. 48 will be about $2 per lineal foot of single track, probably a little less. This, of course, does not include the concrete sub-foundation. The system shown in Fig. 49, of which the writer laid about 2 miles of double track through Washington Street, in the city of Syracuse, with the New York Central standard 80-lb. rail, cost about $2 55 per lineal foot. He is therefore now quite satisfied that the 9-in. girder rail can be devised and laid at less cost and make an infinitely more perfect track.

A. A. Schenck, M. Am. Soc. C. E.—Mr. Katté has given a general statement of his views as regards steam railways in cities and rail sections for them. The compound rail of the New York Central and Hudson River Railroad, to which Mr. North has alluded, was designed for and put in use on Washington Street, Syracuse, in 1893. On this street the railroad company expended $160 000 along an extent of about 7 000 ft. of the street. The rail used is shown in Fig. 49. Objections as to depth and width of flangeway in this design are raised by Mr. North. As regards width of flangeway, this was made practically of indefinite width, by keeping the paving block on the inside of the rail down to the level of the tram rail. There was no slot or flangeway. This, of course, gives a wagon crossing the track much more of a jolt than if the block be kept up to level of top of rail, but for a wagon traveling on the track and attempting to leave it, there is room for the wheel to turn. It has not the objectionable features of the high block, which in connection with the rail head forms a deep, square groove, very difficult for the wheel to leave. Probably Mr. North had this high position of block in view when he referred to a clearance width for the flange. The low position of the block, although it causes a jolt in a wagon crossing at right angles, is the same as is used in asphalt work, where it is not readily practicable to keep the asphalt above the rail. The low block is also undoubtedly undesirable in some respects, not only because of the jolt to the wagon crossing at right angles, but because it leaves at a low level the wagon wheel seeking to turn out, giving it a difficult climb over the rail while in a disadvantageous position for doing so. The Crimmins rail, Fig. 3, introduces the feature apparently best adapted to relieve this trouble, as stated, by the reaction against the rail head, combined with the smooth surface of the metal of the curved flange. Such a smooth sliding surface is impracticable in stone, and it would seem desirable Mr. Schenck

Mr. Schenck. always to have such a curved surface or flange in any street rail section.

In the Syracuse rail, the width of tram rail is only what the old Master Car Builders' minimum of 1886, back to back of wheels, of 4 ft. 5 ins., calls for, keeping the tram rail out to the back of wheel (see Fig. 49). Most of the car wheels of the country were placed when this minimum was in force. The depth of flangeway was put at $1\frac{9}{32}$ ins.; the standard wheel flange is $1\frac{4}{32}$ ins. It will, therefore, be noticed that only $\frac{5}{32}$ in. was allowed for wear of rail and tire. In practice this depth has been found not quite enough to prevent the rolling stock from bearing on the tram rail. The trouble so far has been due to hollow tires only, the rail not having worn appreciably since it was laid. It is sometimes supposed that no hollow tire whatever is allowable. The Master Car Builders' reports and code of rules for repairs to interchange cars call for replacing of wheels only when the tread is worn so hollow as to render breakage probable. On leading railways the practice is to send passenger engines to the shops when treads are hollow from $\frac{3}{16}$ to $\frac{1}{4}$ in., and yard engines when treads are hollow from $\frac{1}{4}$ to $\frac{3}{8}$ in. The writer has measured or taken plaster casts of several treads that were hollow $\frac{3}{8}$ in., and in one case $\frac{1}{2}$ in. was found. While such extreme cases may be against all rule, yet one such engine in a dozen years going over a track, with or against rules, will be sufficient to injure miles of tramway of improper section and flangeway. The false flange of the hollow tread is found also to injure the paving on the outside of rail, either by crushing the blocks or crowding them out of position. Such crowding is not merely by depressing them vertically. The pressure coming on one edge of the block, the tilting action is sometimes demoralizing in many ways. Although the outside blocks might be kept low by the amount of false flange, yet in practice, either in the paving process or from the effects of weather, the blocks will be found high, especially if the track settles at all. The method of carrying the false flange on the rail head by widening the head, relieves this trouble and also allows the flangeway to be made more shallow, as the flange does not settle down in it because of a hollow tire.

The combination of a rail head widened on the outside, with the Crimmins curved flange, and with a web deep enough to avoid chipping the paving blocks, is shown in the new design now being considered by the New York Central and Hudson River Railroad Company. Fig. 48 shows a section of such a combination. The estimated first cost is about 20% less than in the Syracuse plan, and the maintenance cost should be very much less, on account of the reduced number of pieces. The Crimmins rail, apart from the question of bearing for false flange, is not well adapted for heavy railway rolling stock, the head not being over the web, and it was not designed for such use.

Some of the points of enquiry that may be raised in connection with this rail are the strength of the widened head under the false flange; the tendency to tilt, the false flange not being over the web; and the tendency of the curved flange to bend under pressure from the wheel flange. The strengthening of the widened head under the false flange is very cheaply done for any required weight, involving thickening only 2 ins. of the outline. Mr. Schenck.

The tilting tendency is counteracted by the roadway material on each side of the rail, leaving much less duty for the fastenings at the base than with an ordinary 6-in. 100-lb. rail unsupported on either side.

The pressure on the curved flange is measured not by the weight on the wheel, but by the lateral sliding resistance of the opposite wheel. There will rarely be much pressure on the curved flange. With wheels set on the minimum 4 ft. 5 ins., and a worn flange on one wheel, the opposite wheel can get well out on the curved flange, but in this case the curved flange would simply have to act as a guard rail rather than a bearing rail. The low rates of speed in city traffic will greatly lessen the duty of this flange as a guard rail. It can be readily and cheaply increased in section if experience so dictates.

J. M. Evans, Jun. Am. Soc. C. E.—The Department of Public Works in the city of New York during the summer of 1896 adopted and used the following construction for the repaving of First Avenue. The street contains two railroad tracks covering a space of about 16 ft. in the center of the street. On the outside of each outer rail 8 ft. of granite was laid on a 2-in. sand cushion resting on 6 ins. of concrete, when the longitudinal grade of the street was $2\frac{1}{2}\%$ or more. Between the granite strip and the curb 14 ft. of asphalt was laid on the old stone paving blocks, which were in all cases repaved, for a foundation. It is the custom of the Department to set 8-in. and 12-in. toothing stones alternately along each rail. These toothing stones are set directly on concrete mortar and rammed to the level of the tread of the rail before the concrete sets, then the joints are filled with tar and gravel. The tar and gravel joint, however, does not extend entirely around the outer ends of the stone, these ends being banked with moist earth to prevent the tar from running out. This construction was followed in laying the granite next the track, but it was impossible to follow it at the outer edge of the granite strip, as the toothing stones at this point were laid upon the customary 2-in. sand cushion. The traffic over these stones necessary for construction caused them to settle or tip down on the sand foundation, thus leaving a depression at the joint of the asphalt and granite. The toothing stones at this joint were poured with tar, the same as the stones next the rail, that is, about half of the stone received the tar and gravel joint, the other half being left open to receive the asphalt. To pre- Mr. Evans.

Mr. Evans. vent the settling of the toothing on the latter part of the work, the speaker caused the foundation pavement for the asphalt to be first rammed, thus bringing it to a bearing against the toothing, then rammed the toothing into it, and finally made a tar and gravel joint around the entire stone. This securely bound the toothing to the foundation of the asphalt. The result of this method of setting the stones gave entire satisfaction and even surpassed his expectations. He has several times seen a 9-ton roller run over the stones thus set before the asphalt was laid, without depressing them sufficiently to break the bond between them and the next course.

Mr. North. EDWARD P. NORTH, M. Am. Soc. C. E.—An apology is due for the careless description of the steel plate laid on Chambers Street. The edge nearest the rail was laid substantially flush with the toothing stones, which are there laid against the stringers, supporting a center-bearing rail. The surface of the outer edge was depressed about $\frac{3}{4}$ in. below the surface of the asphalt. The holes mentioned were made by a punch which left projections on each side of the plate. These projections took the wear of the wheels next to the toothing, but retained the asphalt between them. At the outer edge of the plate they were covered. A more careful description of the piece of plate would probably have saved some reasoning about its probable inadequacy to prevent the formation of any rut.

Mr. Pratt seems to have adopted an exceptional case for his standard section, showing the pavement on First Avenue. The intention was to have the granite blocks laid just flush and in the same plane with the tread of the rails, and this has been generally accomplished. Fig. 20 is unfortunate, as many readers who are hurried for time pay more attention to cuts than to the text. This figure is also misleading, as no asphalt has been laid either between the rails or between the tracks. That area was paved by and at the cost of the Metropolitan Street Railway Company, and the pavement laid by them illustrates the statement of Mr. Lewis: "The railways will do no more than they are required, and nothing if they can avoid it."

Mr. Waring's statement, which is probably founded on a careful comparison of the cost of areas swept, shows that on sweeping alone there would be a yearly saving of \$500 000 if the streets on which the grades did not forbid were paved with asphalt. This sum, at an interest rate of $3\frac{1}{2}\%$, represents a capital of over \$14 000 000, a sum more than sufficient to put asphalt on all the streets of Manhattan Island where the grade would not be too steep.

As it has been said that the statement: "The laws of the State of New York make it obligatory on all surface roads to pave and keep in repair the space between the rails and tracks and 2 ft. outside of the same," is plainly erroneous; that part of Section 98 referred to, which deals with repaving streets, is quoted, namely:

Mr. North.

Chapter 565, Section 98, Laws 1890, as Amended by Chapter 676, Laws 1892.

"*Repair of Streets; Rate of Speed; Removal of Ice and Snow.*—Every street railroad corporation, so long as it shall continue to use any of its tracks in any street, avenue or public place in any city or village, shall have and keep in permanent repair that portion of such street, avenue or public place, between its tracks, the rails of its tracks, and two feet in width outside of its tracks, under the supervision of the proper local authorities, and whenever required by them to do so, and in such manner as they may prescribe. In case of the neglect of any corporation to make pavements or repairs after the expiration of thirty days' notice to do so, the local authorities may make the same at the expense of such corporation." * * *

This quotation, it is thought, will render unnecessary any future reference to the laws of the State of New York as understood by the surface railway companies in the city of New York.

The advantages of the Stanley rail (Fig. 28), which is substantially of the same section as that used in the District of Columbia, as "the best section of simple girder rail, from the pavement standpoint, yet adopted for streets," are fully recognized; the flange or tram of the rail being of the same height as the tread, and probably presenting mass enough to resist wear about equally with the tread. The vertical sides also are very desirable, but a surface railway company undoubtedly has some rights. Among these is a flange rail that does not entail too much expense from dirt in the slot, nor unnecessarily bind the flanges of the wheel. In other words, the rail shown in Fig. 3 is endorsed as not being onerous to railway companies and at the same time preserving the rights of the public in the highways its money has provided. The sharp edge in Fig. 3 is not, in practice, as objectionable, from the pavement standpoint, as it appears in theory, as the hard terra-cotta fillers used by Mr. W. Boardman Reed, the engineer of the Metropolitan Street Railway Company of New York City, give a very solid bearing for pavement of any kind, and the combination seems to the author much better to pave against than the simple Stanley section, though possibly not better than that section combined with Mr. Reed's filler blocks.

Mr. Victor Angerer apparently contends that there is advantage in keeping the wagon traffic of a city or town on the tracks of surface railways. Such a concentration of traffic, however, must retard the speed of cars and bring an expensive wear on the rails, while broad-gauge wagons develop unsightly, and, in time, costly, grooves in the pavement. The interest of the capital invested in surface railways seems to lie in having the pavement alongside their tracks so hard and even that traction will not be lessened on their tracks, and, at the same time, the rails should present the least possible side friction to the wheels of

Mr. North. wagons that are on them. The provisions for leaving streets dirty seem more inimical to the interests of cities and towns than the proposed concentration of traffic on the rails.

The section of rail proposed by Mr. Katté for freight and passenger roads will interest and please both the engineers having charge of paved streets and those connected with railroads, as its general adoption will remove the weighty objection to the extension of freight tracks in urban localities devoted to such trades and commerce as require the transportation of heavy merchandise.